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PLOD II: Planetary Orbit Determination Program for the IBM 7094 Computer

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JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

April 15, 1965

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ABSTRACT

This Report describes the double precision numerical fitting program for the IBM 7094 used in the computation of the Jet Propulsion Laboratory planetary ephemerides. The method of integration and the least squares fitting technique is described in detail along with all mathematical equations used in the computation.

I. INTRODUCTION

PLOD II is a double precision (DP) program designed to determine a definitive planetary orbit by fitting known source positions for a planet in such a manner that the residuals in longitude and latitude are as small as possible in a least squares sense. The numerical integration used is a DP Cowell finite difference method.

PLOD II is intended to be used with a large number of "observations," i.e., a source ephemeris, and will compute a DP solution of the normal equations for osculating elements by linear stepwise regression, using these differential corrections to correct the epoch elements. It then repeats with the improved epoch values until convergence is obtained, i.e., the sums of squares of residuals in longitude and latitude are as small as possible.

II. DEVELOPMENT

A. General

In the space exploration field it is often required to have planetary ephemerides of position and velocity of high accuracy. The errors inherent in presently used theories prevent the obtaining of accurate velocities by numerical differentiation of tabulations or analytical differentiation of the expansions. Therefore, PLOD II was developed in order to compute a gravitationally consistent position and velocity ephemeris of high accuracy.

B. Specific

In PLOD II, all corrections are in the ecliptic system. In the first version of PLOD (called PLOD I) the residuals

$\Delta x^i = x_0^i - x_c^i$, $(i = 1, 2, 3)$ in equatorial rectangular coordinates (x^i_0 observed values and x^i_c computed values) were reduced by least squares. The criterion of fit was that

$$\sum_{j=0}^{n}\left[\sum_{i=1}^{3}(\Delta x_j^i)^2\right] = \min$$

In PLOD II, for purposes of flexibility and display, it was decided to change the criterion of fit to

$$\sum(\cos\beta\Delta\lambda)^2\alpha_1 + \sum(\Delta\beta)^2\alpha_2 + \sum\left(\frac{\Delta\rho}{\rho}\right)^2\alpha_3 = \min \quad (1)$$

i.e., to fit the longitude, latitude, and radius vector in the ecliptic system, with the option of eliminating the influence of any one of the residuals by assigning appropriate values to α_1, α_2, and α_3. As an example, in fitting observations where distance is not known, it is sometimes desirable to eliminate the influence of the radius vector, and fit only to latitude and longitude. It was also thought best to make corrections to $\pi = \Omega + \omega$, rather than to ω, to avoid difficulties with small inclinations (such as the Earth).

III. METHOD OF SOLUTION

Given epoch conditions of either equatorial rectangular position-velocity coordinates x_0, y_0, z_0, $\dot{x}_0$, $\dot{y}_0$, $\dot{z}_0$, or osculating elements a_0, n_0, e_0, i_0, Ω_0, ω_0, M_0 in the ecliptic or equatorial system, it is desired to determine an orbit which most closely fits a source ephemeris in the least squares sense. If the orbit determination is started with position and velocity as epoch conditions, they are transformed to the ecliptic constants of the orbit, i.e., the direction cosines **PQR** of the three axes and the osculating elements (see Ref. 1). A transformation is then made back to equatorial position velocity coordinates for FORTSZ.

If the epoch conditions are already in terms of the osculating elements in the ecliptic system, then the **PQR**-direction cosine matrix is computed by the following formulas:

$$\begin{aligned}
\mathbf{P}_x &= \cos\omega_0\cos\Omega_0 - \sin\omega_0\sin\Omega_0\cos i_0\\
\mathbf{Q}_x &= -\sin\omega_0\cos\Omega_0 - \cos\omega_0\sin\Omega_0\cos i_0\\
\mathbf{R}_x &= \sin\Omega_0\sin i_0\\
\mathbf{P}_y &= \cos\omega_0\sin\Omega_0 + \sin\omega_0\cos\Omega_0\cos i_0\\
\mathbf{Q}_y &= -\sin\omega_0\sin\Omega_0 + \cos\omega_0\cos\Omega_0\cos i_0\\
\mathbf{R}_y &= -\cos\Omega_0\sin i_0\\
\mathbf{P}_z &= \sin\omega_0\sin i_0\\
\mathbf{Q}_z &= \cos\omega_0\sin i_0\\
\mathbf{R}_z &= \cos i_0
\end{aligned} \quad (2)$$

given a_0, e_0, i_0, Ω_0, ω_0, and M_0 in the ecliptic system. If they are in the equatorial system, they are rotated to the ecliptic system by a solution of spherical triangles (see Ref. 2).

This 3×3 matrix, together with the osculating elements, is constant throughout the integration and corrected at each iteration.

To obtain these elements as the independent variables of the integration, a transformation is performed which converts the elements to position and velocity coordinates for FORTSZ, the integration routine, by a Newton-Raphson iteration which determines a value of E good to full double precision accuracy.

Given the first approximation to Kepler's equation,

$$E = M + e\sin M + \tfrac{1}{2}e^2\sin 2M \quad (3)$$

and Kepler's equation

$$f(E) = E - e\sin E - M \quad (4)$$

then E is found by iterating in the Newton-Raphson equation

$$E_{k+1} = E_k - \frac{f(E_k)}{f'(E_k)} \quad (5)$$

and x, y, z, $\dot{x}$, $\dot{y}$, $\dot{z}$ are found from the equations in Ref. 1 (p. 146).

The x_0, y_0, z_0, $\dot{x}_0$, $\dot{y}_0$, $\dot{z}_0$ ecliptic are now rotated to the equatorial system by premultiplying by a standard rotation matrix.

$$\mathbf{R} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\varepsilon & -\sin\varepsilon \\ 0 & \sin\varepsilon & \cos\varepsilon \end{bmatrix} \tag{6}$$

The equatorial position-velocity coordinates with the elements as independent variables are then used to set up starting values for the Gauss-Jackson predictor corrector method of the Cowell integration scheme. (See Section IF of the Appendix for details and equations.)

The equations of motion to be integrated are the fundamental equations in Cowell's method (Ref. 3, pp. 169–170).

$$\ddot{x}^i = -k^2(1+m)\frac{x^i}{r^3} + \sum_j k^2 m_j \left(\frac{x_j^i - x^i}{(\rho_j)^3} - \frac{x_j^i}{(r_j)^3}\right) \qquad (i = 1,2,3) \tag{7}$$

where

$$(r)^2 = \sum_{i=1}^{3} (x^i)^2$$

$$(r_j)^2 = \sum_{i=1}^{3} (x_j^i)^2$$

$$(\rho_j)^2 = \sum_{i=1}^{3} (x_j^i - x^i)^2$$

and where the x^i are the position coordinates in the three-dimensional system, and m is the mass of the body whose motion is sought, while m_j and x_j^i are the masses and positions of the perturbing bodies. The positions of the perturbing bodies are taken from the EPHEM tape generated by the Jet Propulsion Laboratory (see Refs. 4 and 13). This calculation and the computations involving the relativity contribution for the inner planets are performed in the derivative subroutine, DERIV (see Appendix).

During the integration of the equations of motion the residuals are computed in the subroutine TSTOP at specified time stops. The residuals are first computed as equatorial residuals, i.e.,

$$\Delta x_q^i = x_0^i - x_c^i \qquad (i = 1,2,3) \tag{8}$$

where x_0^i and x_c^i are the observed (the "observed" positions being read from the source ephemeris tape) and computed position coordinates in that order. The Δx_q^i and $x_c^i, \dot{x}_c^i$ equatorial are then rotated by matrix (6) with $\sin\varepsilon = -\sin\varepsilon$ to ecliptic residuals Δx_e^i and ecliptic position and velocity. The ecliptic longitude and latitude, and the quantity ρ are then computed and the residuals in longitude, latitude, and ρ are formed from the following equations:

$$\begin{aligned} \rho\cos\beta\Delta\lambda &= -\sin\lambda\Delta x_e^1 + \cos\lambda\Delta x_e^2 \\ \rho\Delta\beta &= -\sin\beta\cos\lambda\Delta x_e^1 - \sin\beta\sin\lambda\Delta x_e^2 + \cos\beta\Delta x_e^3 \\ \rho\Delta\rho &= x_e^1\Delta x_e^1 + x_e^2\Delta x_e^2 + x_e^3\Delta x_e^3 \end{aligned} \tag{9}$$

For convenience in setting up the normal equations, the equations are stored in the following matrix form:

$$\bar{\mathbf{B}} = \mathbf{C}\mathbf{R}_x \tag{10}$$

where $\mathbf{C}$ is the matrix of coefficients on the right side of Eq. (9) multiplied by $1/\rho$, $\mathbf{R}_x$ is the residual matrix, and the last row of the matrix has been divided by ρ for scaling.

$$\bar{\mathbf{B}} = \begin{bmatrix} \cos\beta\Delta\lambda \\ \Delta\beta \\ \dfrac{\Delta\rho}{\rho} \end{bmatrix} = \frac{1}{\rho}\begin{bmatrix} -\sin\lambda & \cos\lambda & 0 \\ -\sin\beta\cos\lambda & -\sin\beta\sin\lambda & \cos\beta \\ \dfrac{x_e^1}{\rho} & \dfrac{x_e^2}{\rho} & \dfrac{x_e^3}{\rho} \end{bmatrix}\begin{bmatrix} \Delta x_e^1 \\ \Delta x_e^2 \\ \Delta x_e^3 \end{bmatrix} \tag{11}$$

The residuals in Δx_q^i equatorial and $\cos\beta\Delta\lambda$, $\Delta\beta$, $\Delta\rho/\rho$ ecliptic are now tabulated and the latter are used in setting up the normal equations.

The integration yields position coordinates $x^i(t, \mathbf{c})$ and velocity components $\dot{x}_i(t, \mathbf{c})$, $(i = 1,2,3)$, at time stop points $t_0 < t_1 < t_2 < \cdots \leq t_n$. The computed coordinates in general depend on some parameter set $\mathbf{c} = (c_1, c_2, \cdots, c_6)$, the six constants of integration. In this Report, these constants will be the osculating elements mentioned above. This parameter set serves to fix the values of the coordinates and velocity components at t_0. The $\mathbf{c}$ are chosen such that the sum of the squared residuals (S_1) is a minimum. As in PLOD I,

$$S_1 = \sum_{j=0}^{n}\left[\sum_{i=1}^{3}(\Delta x_j^i)^2\right] = \min \qquad (i = 1,2,3) \tag{12}$$

or in the case of PLOD II,

$$S_2 = \sum_{j=0}^{l}\alpha_1(\cos\beta_j\Delta\lambda_j)^2 + \sum_{j=0}^{m}\alpha_2\Delta\beta_j^2 + \sum_{j=0}^{n}\alpha_3\left(\frac{\Delta\rho_j}{\rho_j}\right)^2 = \min \tag{13}$$

The usual method of minimizing S_1 is to calculate the partial derivatives $\partial x_j^i/\partial c_k$, $(i = 1, 2, 3)$, $(k = 1, 2, \cdots, 6)$, for assumed values of the c_k and at the points t_j, and to solve the normal equations

$$\sum_{k=1}^{6}\left[\sum_{j=0}^{n}\left(\sum_{i=1}^{3}\frac{\partial x_j^i}{\partial c_m}\Delta x_j^i\right)\right] = \sum_{k=1}^{6}\left[\sum_{j=0}^{n}\left(\sum_{i=1}^{3}\frac{\partial x_j^i}{\partial c_m}\frac{\partial x_j^i}{\partial c_k}\right)\right]\Delta c_k \qquad (m = 1, 2, \cdots, 6) \qquad (14)$$

for corrections Δc_k to the values of c_k.

In PLOD I the partial derivatives appeared in a single equation of condition in matrix form (see Ref. 3, Chap. 9) where **A** is the 3×6 matrix of partial derivatives. This may be denoted explicitly by the following matrix where the traditional notation x, y, z is used for the position and velocity vectors for convenience of expression:

$$\mathbf{A} = \begin{bmatrix} \frac{\dot{x}}{n} & \mathbf{P}_y z - \mathbf{P}_z y & \mathbf{Q}_y z - \mathbf{Q}_z y & \frac{1}{e}\left(\frac{-\dot{x}}{n} + \mathbf{R}_y z - \mathbf{R}_z y\right) & x - \frac{3}{2}t\dot{x} & Hx + K\dot{x} \\ \frac{\dot{y}}{n} & \mathbf{P}_z x - \mathbf{P}_x z & \mathbf{Q}_z x - \mathbf{Q}_x z & \frac{1}{e}\left(\frac{-\dot{y}}{n} + \mathbf{R}_z x - \mathbf{R}_x z\right) & y - \frac{3}{2}t\dot{y} & Hy + K\dot{y} \\ \frac{\dot{z}}{n} & \mathbf{P}_x y - \mathbf{P}_y x & \mathbf{Q}_x y - \mathbf{Q}_y x & \frac{1}{e}\left(\frac{-\dot{z}}{n} + \mathbf{R}_x y - \mathbf{R}_y x\right) & z - \frac{3}{2}t\dot{z} & Hz + K\dot{z} \end{bmatrix}_{3\times 6} \qquad (15)$$

where

$$H = \frac{r - a(1 + e^2)}{ae(1 - e^2)}$$

and

$$K = \frac{r\dot{r}}{a^2 n^2 e}\left[1 + \frac{r}{a(1 - e^2)}\right]$$

The actual matrix equation for one time point would be represented by

$$\mathbf{AX} = \mathbf{B} \qquad (16)$$

where

$$\mathbf{X} = \begin{bmatrix} \Delta M_0 + \Delta r \\ \Delta p \\ \Delta q \\ e\Delta r \\ \Delta a/a \\ \Delta e \end{bmatrix}_{6\times 1} \qquad (17)$$

and

$$\mathbf{B} = \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \end{bmatrix}_{3\times 1} \qquad (18)$$

and all quantities are in the equatorial system.

In PLOD II, since S_2 is minimized, the matrix form is slightly modified. Recalling Eq. (15), matrix A is multiplied by the matrix

$$\mathbf{C} = \frac{1}{\rho}\begin{bmatrix} -\sin\lambda & \cos\lambda & 0 \\ -\sin\beta\cos\lambda & -\sin\beta\sin\lambda & \cos\beta \\ \mathrm{x}/\rho & \mathrm{y}/\rho & \mathrm{z}/\rho \end{bmatrix} \qquad (19)$$

obtaining a new matrix of partial derivatives

$$\overline{\mathbf{A}} = \mathbf{CA} \qquad (20)$$

and a new system of equations in matrix form

$$\overline{\mathbf{A}}\mathbf{X} = \overline{\mathbf{B}} \qquad (21)$$

where **X** is the column vector

$$\mathbf{X} = (\Delta M_0 + \Delta r, \Delta p, \Delta q, e\Delta r, \Delta a/a, \Delta e) \qquad (22)$$

and $\overline{\mathbf{B}}$ is now the column vector $\overline{\mathbf{B}} = (\cos\beta\Delta\lambda, \Delta\beta, \Delta\rho/\rho)$ of the longitude and latitude residuals in the ecliptic system. The position and velocity coordinates for the Set III matrix, i.e., the A matrix, are also in the ecliptic system. Hence, there is in symbolic notation a 3×6 matrix $\overline{\mathbf{A}}$ equal to the partial derivatives of λ, β, and ρ with respect to the Set III of Brouwer and Clemence.

$$\overline{\mathbf{A}}_{3\times 6} = \mathbf{C}_{3\times 3}\mathbf{A}_{3\times 6} = \frac{\partial(\lambda, \beta, \rho)}{\partial(\text{Set III})} \qquad (23)$$

These partial derivatives will be formed at each of the $n + 1$ steps.

Due to the large number of points at which $\overline{\mathbf{A}}$ is computed, it is necessary to use a special method of solving the system of equations obtained. (See Ref. 5.)

Let the system of linear equations obtained after $n + 1$ steps be denoted by

$$NX = F \tag{24}$$

where $\mathbf{X}$ is the solution vector and N is defined by

$$N = \sum_{j=0}^{n} \Delta N_j \tag{25}$$

and

$$\Delta N_j = \bar{\mathbf{A}}_j^* \mathbf{W} \bar{\mathbf{A}}_j \tag{26}$$

at each step. $\bar{\mathbf{A}}^*$ is the transpose of $\bar{\mathbf{A}}_j$, and $\mathbf{W}$ is a diagonal weight matrix, i.e.,

$$\mathbf{W} = \begin{bmatrix} \alpha_1 & 0 & 0 \\ 0 & \alpha_2 & 0 \\ 0 & 0 & \alpha_3 \end{bmatrix} \tag{27}$$

The matrix $\mathbf{W}$ plays the role of excluding the influence of any one of the residuals. If in PLOD II the longitude and latitude residuals only are minimized, then the setting of $\alpha = (1, 1, 0)$ annihilates the contribution of the ρ residual. If a PLOD I type of fit is desired, the setting of $\alpha = (1, 1, 1)$ will again make the ρ contribution significant and STPRG2 will correct accordingly.

The matrix $\mathbf{F}$ is defined by

$$\mathbf{F} = \sum_{j=0}^{n} \Delta \mathbf{F}_j \tag{28}$$

where

$$\Delta \mathbf{F}_j = \bar{\mathbf{A}}_j^* \mathbf{W} \bar{\mathbf{B}}_j \tag{29}$$

at each step.

The equations $N\mathbf{X} = \mathbf{F}$ are then solved by a DP stepwise regression program called STPRG2 (see Section IF of Appendix), if the value of S_2 as computed by

$$S_2 = \sum_{j=0}^{n} \alpha_1 (\cos \beta_j \Delta\lambda_j)^2 + \alpha_2 (\Delta\beta_j)^2 + \alpha_3 \left(\frac{\Delta\rho_j}{\rho_j}\right)^2 \tag{30}$$

is too large, or if TMAX, the maximum number of time steps allowed for the integration, has been reached. The final convergence test is performed on the usual convergence factor

$$SQ = (S_2/N)^{1/2} \tag{31}$$

where N is the total number of integrated positions.

The solution column vector [Eq. (22)] will then be the desired corrections to the osculating elements. The corrections Δr, ΔM_0, Δa, and Δe are easily obtained in a straightforward manner from $\mathbf{X}$, the solution vector, while n is obtained from a unless the mean motion is held fixed. (It should be noted here that if the mean motion is held fixed, then the correction to the period is ignored. The column corresponding to $\Delta a/a$ in the overdetermined system of linear equations is set equal to zero, and therefore, STPRG2 makes no attempt to solve for $\Delta a/a$. The value of a is then held fixed through Kepler's third law.) The only difficulty lies in obtaining corrections to $\Delta\Omega$, Δi, and $\Delta\omega$, the longitude of the ascending node, the inclination, and the argument of perihelion. This may be accomplished in the following manner:

Let the corrections to i and Ω be expressed as: (For a derivation of these results see Ref. 3, pp. 238–239.)

$$\begin{aligned} \Delta i &= \Delta p \cos\omega - \Delta q \sin\omega \\ \sin i \Delta\Omega &= \Delta p \sin\omega + \Delta q \cos\omega \end{aligned} \tag{32}$$

An expression for $\Delta\omega$ may be similarly derived, but in order to accurately determine $\Delta\omega$ from a correction to the longitude, it is more desirable to find the correction to $\Delta\pi = \Delta\omega + \Delta\Omega$, and then subtract the computed value of $\Delta\Omega$ found from Eq. (32). By examining small rotations Δp, Δq, Δr and making trigonometric substitutions, it may be found that a small change in $\Delta\pi$ may be expressed as follows:

$$\Delta\pi = \frac{\sin i}{(1 + \cos i)} (\sin\omega \Delta p + \cos\omega \Delta q) + \Delta r \tag{33}$$

from which $\Delta\omega$ may be computed after $\Delta\Omega$ is found. This brings up the inherent difficulty of what to do with $\sin i$ when i is near zero. The problem is attacked by setting $\Delta\Omega \equiv 0$ whenever $i < \epsilon$, or zero. Hence, from the corrections Δp, Δq, Δr, it is possible to obtain $\Delta\omega$, $\Delta\Omega$, and Δi and complete corrections to the osculating elements.

The new elements are now computed and used in Eq. (2) to compute new direction cosines, from which new epoch values of position and velocity $(x_0\, y_0\, z_0, \dot{x}_0\, \dot{y}_0\, \dot{z}_0)$ may be computed and the integration may be started again. The process is complete when Eq. (31) has a value of $SQ \leq \epsilon$, where ϵ is a predetermined number, or when there are no further appreciable corrections from the least squares stepwise regression solution, i.e.,

$$\sum (\cos\beta\Delta\lambda)^2 \alpha_1 + \sum (\Delta\beta^2) \alpha_2 + \sum \left(\frac{\Delta\rho}{\rho}\right)^2 \alpha_3 = \min \tag{34}$$

APPENDIX I. PLOD II USERS MANUAL

A. Description

PLOD II is to be used on the standard Fortran II monitor system of the IBM 7094. It is a DP program employing DP subroutines to do most of the major computation. The storage required by PLOD II is considerable and the program uses most of the cells available in the 7090 94 memory unit under Fortran II. Caution is therefore advised when new subroutines are added or old ones modified. The following user's manual is a complete description of PLOD II with all necessary information for ephemeris computation, and includes listings of the main programs. The user should be particularly interested in the data deck and control card Section.

B. Operating Instructions

PLOD II is a self-contained program that requires no console monitoring. The program reads all control information from the data deck and will call for tapes when needed. PLOD II uses five nonsystem tape channels. The source and perturbing body tapes are read on two channels while the PV tape, the preconverged residual tape, and the converged residual tape are written on the remaining three channels. The user selects the channels. The source ephemeris tape and perturbing body tapes are always called immediately while the other tapes are not called unless it is necessary to write an ephemeris or residual tape and the integration has converged. (The exception here is the preconverged residual tape. If this option is used, PLOD II will write immediately a residual tape for the first, $n - 1$, iterations.) The program prints out on-line, for convenience, the value of sigma and the Julian date at each iteration, and if there is no improvement, the program may be stopped by requesting the operator to halt.

It is to be noted here that the average run may take from 20 to 120 min for a 50-yr integration with three or four iterations, depending upon the body being integrated, the integration step size, and the residual step size. An estimate of the number of integration steps per minute would be 250.

The order in which the subroutines are loaded is important under Fortran II. The subroutines FORTSZ, XPAND, SMULT, SCALR, and INTRP must be loaded first in that order. This insures that all DP instructions refer to even locations. The others, including PLODMN, may be loaded in whatever order desired.

C. Descriptions of Input

1. Orbital Input Information

The basic frame of reference to which all elements and rectangular position and velocity coordinates are referred is the fixed equator and equinox of 1950, Julian date, 2433282.423. PLOD II may be started with rectangular heliocentric equatorial coordinates read from cards, tape, or osculating elements, either in the ecliptic or equatorial system read from cards. If the osculating elements are in the equatorial system, a control parameter must be set to rotate them to the ecliptic system. Although the integration is always carried out in the equatorial system, all other computations, corrections, and internal starting values are in the ecliptic system.

The osculating elements a, n, e, i, Ω, ω, M, referred to throughout the program, are actually the independent variables of the differential correction procedure. In any case in the starting procedure, the rectangular coordinates are found from these values. In fact, any unperturbed orbit of a planet about the Sun is completely defined by six elements which may be chosen in various ways and which may be referred to any reference system. The elements used by PLOD II are defined as follows:

- a the semimajor axes of the orbit.
- n the mean daily motion. n and a are related by $n^2a^3 = k^2(1 + m)$, where k is the Gaussian gravitational constant and m is the mass of the main body expressed in terms of the Sun's mass.
- e the eccentricity of the orbit.
- i the inclination of the orbit to the ecliptic.
- Ω the longitude of the ascending node of the orbit on the ecliptic, measured from the equinox.
- ω the argument of perihelion. Even though ω is inputted to PLOD II, the corrections are made in $\pi = \Omega + \omega$, the longitude of perihelion, measured from the equinox along the ecliptic to the node, and then along the orbit from node to perihelion.
- M_0 the mean anomaly at epoch.

The element n is not independent since it is related to a. It may be input by cards to the program, but more commonly is computed directly from a. There is an option

to force n to be the input value when desired. When this is the case, a is computed from n and the SET III matrix is computed accordingly, i.e., the column vector on which a depends is set to zero.

The reciprocal masses of the planets are input to the main program of PLOD II. They are inverted in DP within the program and the values of μ and $\mu^{\frac{1}{3}}$ is computed in DP also. The gravitational constant, k, is compiled internally and k^2 is also computed in DP.

The value $k = 0.017202\ 098950\ 000000$ is taken from Ref. 1, p. 58. The mass of the Earth is immediately set to zero along with the main body of the integration. There is no need for the mass of the Earth at this time, since all work is done with the Earth-Moon barycentre.

2. Data Deck and Control Cards

The description of the data deck and control cards will be outlined into four main groups. The outline includes format specifications and control information and all of the PLOD II options with explanations. The user will be primarily concerned with this section, and it is recommended that some form of data sheet be set up for production runs, since only a few of the cards will be changed for different cases.

The four main groups are arranged according to the type of input. Group one, the identification group, includes general information such as the planet to be integrated, source tapes for the planet, PV write tapes, source tape for the perturbing bodies, and BCD identification records for the ephemeris and residual tapes. Group two is mainly input options and printing options for the ephemeris tape, i.e., PV tape generated by PLOD II, as well as information for FORTSZ control options. Input options include indications of what system the data are in, ecliptic or equatorial, whether on cards or tape, and whether the mean motion is held fixed or not. Group three consists primarily of convergence tolerances that are input by the programmer. This includes the main convergence criterion and the step size for the normal equations and the PLOD II ephemeris. Group four is the actual orbital information input, which includes epoch conditions, i.e., either the osculating elements or position and velocity coordinates. The reciprocal masses of the planets, the mean motion, the mass increment for augmenting the Sun's mass, the weight vector W, the light constants for the relativity contribution (at the present time, these are not used), and the Julian dates for which the integration is desired are also input here.

a. PLOD II data card format.

Group one (Identification).

The first card (Format 2I4, 2A6) contains the word JEND, the body number NBODY, and the name of the planet being integrated. If JEND = 0, the program will read only one data deck. If JEND = IX, where IX < 0 or IX > 0, IX an integer, the program will read a new data deck. The body number, NBODY corresponds to the number of the planet which is to be integrated, i.e., Mercury = 1, Venus = 2, Earth-Moon = 3, Mars = 4, Jupiter = 5, Saturn = 6, Uranus = 7, Neptune = 8, and Pluto = 9. PLANET (I = 1, 2) are the two BCD words of storage for the planet name, i.e., Mercury, Venus, Earth-Moon, etc.

The second card contains tape information for four tapes and the Fortran logical unit number for the preconverged residual tape:

1. COORD tape
2. SOURCE tape
3. PLOD ephemeris write tape
4. PLOD residual write tape

} Format 4 (I3, A6, A3) where I3 is logical unit number, A6 is tape number, and A3 is channel number.

5. Preconverged $(n - 1)$ iterations residual tape logical unit. Format (13).

Cards 3 through 12 contain BCD information and comments on the PLOD run (in groups of two cards). There will be 12A6 words on the first card and 10A6 words on the second card. The programmer may write a sentence of information with blanks wherever he chooses, as long as he ends in column 72 on the first card, and in column 60 on the second card (column 1 must be left blank on every card). The following is a specific list of the cards taken two at a time:

1. Cards 3 and 4 contain the BCD record identification for the PV ephemeris generated by PLOD II. The comment must end with the words "PLANET IS," or words to that effect, since the next word will be the name of the planet.

2. Cards 5 and 6 comment on COORD tape.

3. Cards 7 and 8 comment on SOURCE tape.

4. Cards 9 and 10 contain the BCD record identification for the PV residual tape generated by PLOD II.

5. Cards 11 and 12 contain the BCD record identification comment for preconverged residual tape. It is advisable to include dates and tape numbers in all cases.

Group two.

Control options: Input and ephemeris print.

Card 13: Format (14I4)

KAM = 1 Rotates source XYZ to ecliptic, computes ρ, λ, β, prints, and computes $\Delta\rho, \Delta\lambda, \Delta\beta$ for check.

KAM = 2 No rotation, print, or $\Delta\rho, \Delta\lambda, \Delta\beta$ check.

LAM = 1 Prints $XJD, XYZ, \dot{X}\dot{Y}\dot{Z}$, and $\Delta X, \Delta Y, \Delta Z$ during iteration.

LAM = 2 No print during iteration.

NAM = 1 Derivative print during dates specified for position, velocity, and acceleration.

NAM = 2 No print.

MAM = 1 Load COORD tape (MTAPE) only

MAM = 2 Load SOURCE tape (NTAPE) only.

MAM = 3 Load COORD (MTAPE) and SOURCE (NTAPE) tapes (usual case).

JAM = 1 PROG solves normal equations after TMAX (usual case).

JAM = 2 Will be automatically set not to call STPRG2 after convergence.

K = 8 (Leave alone.)

NOBOD = 10 For COORD in DERIV (will stay constant). Generally not used in PLOD II, since it does not employ old COORD system.

KPOS = 1 Position only from COORD (usual case). Generally not used in PLOD II, since it does not employ old COORD system.

KPOS = 2 Velocities only.

KPOS = 3 Velocity and position.

MEAN = 1 Mean motion is computed internally.

MEAN = 2 Mean motion is inputted and remains fixed throughout integration.

ITRMAX = Maximum number of iterations allowed (usually set at 8).

NEPOCH = 1 Input by cards $XYZ, \dot{X}\dot{Y}\dot{Z}$ (last two cards) DPINPT DP DEC 16 Digit.

NEPOCH = 2 Input by cards $a_0, n_0, e_0, i_0, \Omega_0, \omega_0, M_0$ (last two cards) DPINPT DP DEC 16 digit.

NEPOCH = 3 Input by reading SOURCE tape for position and velocity.

NDOP = 1 (For PLOD II, NDOP is constant = 1.) Applicable to PLOD I only.

NDOP = 2 PLOD I, NDOP = 1, normal matrix is (3, 6), NDOP = 2, normal matrix is (6, 6). Applicable to PLOD I only.

NECLPT = 1 If elements are ecliptic (no rotation). Applicable only under NEPOCH = 2.

NECLPT = 2 If elements are equatorial, rotate to ecliptic. Applicable only under NEPOCH = 2.

KAN = 1 Print $XJD, XYZ, \dot{X}\dot{Y}\dot{Z}$, and $\Delta X, \Delta Y, \Delta Z$ on converged iteration (last).

KAN = 2 No print of $XJD, XYZ, \dot{X}\dot{Y}\dot{Z}$, and $\Delta X, \Delta Y, \Delta Z$ on converged iteration (last).

FORTSZ Options.

Card 14: Format (5I4, F12.6, E17.8)

MD = M $1 \leq M \leq 15$. Fixed point integer directing highest order of difference to be carried (usual case MD = 8).

JD = J $0 \leq J \leq M$. Initialization point $J = 0$ place at end of net (usual case $J = 0$).

ND = N = 0 No variational equations.

NPT = OPT = 0
Gauss-Jackson open method.

NPT = OPT = 1
Gauss-Jackson pseudo predictor corrector.

NPT = OPT = 2
Gauss-Jackson predictor-corrector (always used).

IL = F = 0 FORTSZ computes only position at TSTOP.

IL = F = 1 FORTSZ computes position and velocity at TSTOP.

H = Integration step size.

ES = -0.1×10^{-11} convergence test for FORTSZ starting procedure (note negative value).

Control options: Tape writing, normal equations, body number, etc.

Card 15: (Format (10I3)

MMAX = 3
NMAX = 6
} These remain constant for PLOD II.

MPRINT = 1 Will write a preconverged residual tape for $(n-1)$ iterations.

MPRINT = 2 Preconverged residual tape not written.

NPRINT = 1 Load and write PLOD ephemeris and residual tape (LTAPE, KTAPE).

NPRINT = 2 Load and write PLOD ephemeris only (LTAPE).

NPRINT = 3 Load and write PLOD residual only (KTAPE).

NPRINT = 4 Do not load and write ephemeris or residual tapes.

KPRINT = 0 No STPRG2 print.

KPRINT = 1 Print STPRG2 summary, final solution only.

KPRINT = 2 Print STPRG2 summary, every solution.

KPRINT = 3 Full print of STPRG2.

NSTEP = 1 For COORD tape only, reads two dates from COORD tape and computes tape step size for DERIV.

NSTEP = 2 Reads BCD heading on SOURCE tape and positions tape. prints on line and off line BCD heading of SOURCE tape.

NSTEP = 3 Reads BCD heading on SOURCE tape and prints same on line and off line, and positions SOURCE tape, then reads two dates from COORD tape and computers tape step size for DERIV.

NSTEP = 4 Reads neither COORD or SOURCE (Note: Leave at 3).

NEPHM = 0 Program goes through normal equations and after convergence sets NEPHM = 1.

NEPHM = Some integer $\neq 0$, if non-zero, simple integration without correction of normal equations.

NEARTH = 1 (leave at 2)

NEARTH = 2

MTEST = 1 Circle test, all masses set to zero.

MTEST = 2 Normal case, only principal mass = 0.

NREL = 1 Compute relativity contribution in DERIV.

NREL = 2 No relativity.

Group three (convergence tests).

Card 16: Format (4E17.8)

STEST = $5. \times 10^{0}$
Test to see if residuals are too large (set at whatever tolerance desired).
SIGSQ $\geq$ STEST Correct orbit
SIGSQ < STEST Continue to TMAX

EPSILN* = $2. \times 10^{-6}$
SIG < EPSILN converge
SIG > EPSILN iterate (Set at whatever tolerance desired; 2×10^{-6} is just a starting guess).

CD = $1. \times 10^{-8}$
Tolerance in STPRG2 for relative reduction in magnitude of diagonal elements of matrix.

SDOUT = 0.005
Significance level (out) of STPRG2 (may be set at 0.0).
STPRG2* convergence (STPRG2 will always give a solution if SDOUT = 0.0, SDIN = 1XE-17).

*The three main convergence tests of the program.

Card 17: Format (2E17.8, 2F12.6)

SDIN = 0.25 > SDOUT significance level (in) of STPRG2.

DEPSIL = $1. \times 10^{-11}$
If epsiln is small, and if successive sigmas are not different in eleventh place converge. The programmer may select his own tolerance after a few runs.

FSTOP1 = Step size for normal equations.
FSTOP1 ≧ Step size of source tape.
FSTOP1, FSTOP2 must be greater than or equal to integration step size.

FSTOP2 = Step size for PLOD ephemeris. At present FSTOP2 ≧ step size of source tape. FSTOP1, FSTOP2 must be greater than or equal to integration step size.

Group four (input data values for execution).[**]

Card 18: Format (DPINPT)

DEC x.x, x.x, x.x
Three dimensional DP, weight vector for normal matrix.

$$W = (\alpha_1, \alpha_2, \alpha_3), (0 \leq \alpha_3 \leq 1.0)$$

$\alpha_3 = 0.0$ Normal case (ρ not significant).

$\alpha_3 = 1.0$ ρ significant (PLOD I type).

Card 19: Format (DPINPT)

DEC 299773 CAR
Constants to compute velocity of light for relativity.

Card 20:

DEC 149598845 AU
Constants to compute velocity of light for relativity.

Card 21: Format (DPINPT)

DEC xxxxxxx.x XTS
Beginning print date for DERIV.

Card 22: Format (DPINPT)

DEC xxxxxxx.x XTE
End print date for DERIV.

Cards 23 and 24: Format (DPINPT)

DEC $(DM(I), I = 1, 10)$
The DPINPT reciprocal masses of the nine planets including the Earth as mass number four, i.e., there will be ten values in the following order: Mercury, Venus, Earth-Moon, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto. Any value may be used for the Earth, since it will be set to zero by the program.

Card 25: Format (DPINPT)

DEC RM The DPINPT inputted mass increment for augmenting the mass of the principal planet being integrated. This value must be read in as zero if no variation in the mass is planned. That is, it is computed in the equation for μ at all times as follows:

$$\mu = k^2(1 + m_i + RM_i)$$

where RM_i is the mass increment and m_i is the mass of the principal planet. If it is desired to use this option for an integration of the outer planets, similar to Ref. 6, then the masses of the four inner planets on Card 23 must be set to zero.

Card 26: Format (DPINPT)

DEC The DPINPT inputted mean motion XMEAN. This may be set to any value if MEAN = 1.

Card 27: Format (DPINPT)

DEC xxxxxxx.x *XJD*
Integration epoch Julian date.

Card 28: Format (DPINPT)

DEC xxxxxxx.x TMAX
Julian date signifying end of integration.

Cards 29 and 30, $\cdots N$

[**]For format description of DPINPT and DOUTPT, see Section F-23 and F-24.

The DPINPT epoch input data. Either position and velocity or the seven osculating elements of the integration.

END OF FILE.

D. Descriptions of Output

PLOD II output may be separated into three main categories:

1. The Starting Values (Epoch Values) and Control Parameters

Here the position and velocity coordinates are listed along with the direction cosine matrix and the osculating elements. The osculating elements and the direction cosine matrix are generally printed in the ecliptic system and the equatorial system at the beginning of every run and at each iteration. For a typical case where the epoch position and velocity coordinates were read from the source tape, there would be the following general outline of identification.

The first value printed is the residual weight vector, defined by Eq. (27), followed by a printed tape identification of the main tapes that are loaded, the perturbing bodies tape and the source tape, and the BCD heading from the source tape. The masses of the planets are then printed in DP in the following order: Mercury, Venus, Earth-Moon-Barycentre, Earth (this will be zero for PLOD II), Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. These are the actual masses of the planets, i.e., the inverse of the inputted reciprocal mass. Next, the control parameters for PLOD II will be labeled. They are defined in the input section of this Appendix, Section C-2. After the control parameters, the BCD record of the preconverged residual tape is printed if the tape is to be written. The epoch values are then read in and printed out in DP, and a comment is printed to the effect that all input data have been read in by PLOD II. The epoch values will in general be either the position and velocity read from cards or tape (the particular case being herein described is of two lines of DP words representing XYZ, and $\dot{X}\dot{Y}\dot{Z}$), or the seven oscillating elements a_0, n_0, e_0, i_0, Ω_0, ω_0, M_0 in the order read from the cards. A comment will be printed indicating what procedure was used and whether the mean motion is inputted and held constant or computed internally.

2. The Information Printed at Each Iteration

The amount of output at each iteration is largely determined by the user, but there are a few values that are automatically printed at every iteration including the first. The beginning of the iteration will be signified by the comment "BEGIN ITERATION." Then the position velocity coordinates at epoch are printed in two lines of three DP words each—first XYZ and second $\dot{X}\dot{Y}\dot{Z}$. In the first iteration, these will be the same as the input coordinates, but in all subsequent iterations they will be the coordinates actually given to the integration routine, i.e., they will have the osculating elements as the independent variables.

The next line of print will be the equatorial osculating elements computed by the subroutine ELEMTS from the position velocity coordinates in DP in the following order: a_0, n_0, e_0, i_0, Ω_0, ω_0, M_0, followed by the computed equatorial DP direction cosines matrix, **PQR**. The **P** vector forms the first row, while the **Q** and **R** vectors form the second and third rows, respectively. The osculating elements and the **PQR** direction cosines matrix are then repeated in the ecliptic system, followed by, for the first iteration only, ecliptic position and velocity coordinates with the osculating elements as independent variables that are rotated to equatorial position-velocity coordinates and given to FORTSZ to start the integration. In all subsequent iterations, the ecliptic position and velocity coordinates will not appear at this point, but will appear just before the comment "BEGIN ITERATION."

A comment is now printed identifying the ephemeris format to be used. An ephemeris consisting of two lines of information is printed on option at each iteration. The first line will always be Julian date, equatorial XYZ, $\dot{X}\dot{Y}\dot{Z}$, and residuals $\Delta X, \Delta Y, \Delta Z$ of observed minus-computed rectangular equatorial coordinates in single precision, followed by ecliptic XYZ, $\dot{X}\dot{Y}\dot{Z}$, and residuals $\Delta\rho$, $\cos\beta\Delta\lambda$, and $\Delta\beta$. The residuals will have a fixed format of 7PF14.4. An additional check may be computed and printed by setting the input parameter KAM = 1, thus printing independently computed $\Delta\rho$, $\Delta\beta$, and $\Delta\lambda$ residuals directly.

When the integration stops either by exceeding TMAX, or by exceeding the residual tolerances set beforehand by input, the normal equations are solved by STPRG2 and a summary is printed by STPRG2 indicating the order of solution and the significance of each coefficient in the solution vector. For KPRINT = 0, 1, 2, or 3, there will be no print of STPRG2, a summary of the final solution, a summary of every solution, or a full print of the matrix and a summary of every solution printed.

This concludes the options allowed at each iteration, with what follows printed at every iteration of PLOD II.

The subroutine CORECT which computes the corrections to the osculating elements now prints the following information: The DP value of $\pi = \omega + \Omega$ is printed first, followed by the uncorrected **PQR** matrix and the uncorrected elements all in the ecliptic system and with the same order as above. Next, the DP solution vector from STPRG2, the new corrected **PQR** matrix, the elliptical corrections to the elements, and the new ecliptic DP elements are printed, again in the same order as above. The final value of μ from Kepler's third law is printed for reference.

A comment is now printed indicating whether the integration has converged or not, the Julian date, the elapsed time in days, the number of integration steps, and the value of sigma and the sum of the squared residuals. A brief summary of statistical analysis is also printed here. The mean deviation, the sum of the squared residuals, the standard deviation, and the maximum and minimum of Δx, Δy, and Δz are printed, plus the same statistics for $\Delta\rho$, $\cos\Delta\lambda$, and $\Delta\beta$. This enables the user to have some idea of the least squares fit at each iteration. These values are also printed on the summary page of the final converged iteration.

3. The Final Output and the Summary Page

The final and most important output is the ephemeris output after convergence. PLOD II will output at the user's option an ephemeris tape and a residual tape after convergence is signified by a printed comment similar to the one described above. PLOD II can write two tapes, one of which will be a residual tape containing a BCD heading of 24 words (supplied by the user in input data), followed by one binary record of 7 words with subsequent records consisting of the DP Julian date at each step, plus the corresponding equatorial residuals of ΔX, ΔY, ΔZ and $\Delta\rho\cos\beta\Delta\lambda$, $\Delta\beta$, in single precision, making an eight-word Fortran binary record at each step. The other tape will be the PLOD II position-velocity (PV) tape which will again have a BCD heading of 24 words followed by a binary record of 7 words and will consist of a DP Julian date, X, Y, Z and $\dot{X}, \dot{Y}, \dot{Z}$, all in DP, making a Fortran binary record size at each step of fourteen words. Simultaneously, at the user's option, the program will print for observation at each step, the Julian date, the position and velocity equatorial coordinates with equatorial $\Delta X, \Delta Y, \Delta Z$ residuals, and ecliptic position-velocity coordinates with the $\Delta\beta$, $\Delta\rho$ and $\cos\beta\Delta\lambda$ residuals. These values may also be printed through each iteration, in order for the programmer to observe the integration and its effect on the residuals. The numbers of the tapes used are printed for identification and easy verification. For complete detail of printing options, the user is advised to consult the data deck and control cards Section (C-2 of this Appendix).

The summary page printed by PLOD II is a reference record to indicate the information necessary for duplicating a PLOD II run. It may be torn off after each PLOD II run and kept in the access file for future reference. The summary page consists of a BCD comment on the PLOD II run and a BCD comment on the COORD tape used for the perturbing bodies, followed by most of the input options necessary to restart PLOD II. These are followed by BCD headings on the converged ephemeris and residual tapes, if these were written, or the comment "NO TAPES WRITTEN," if they were not. The inputted inverse masses are then printed, followed by the weight vector described in the input Section and the angle of obliquity. The converged epoch values are then printed in DP, i.e., the osculating elements, the **PQR** matrix at epoch, and the epoch positions and velocities are printed, each in the order described above. The last printed output is again the summary of statistical analysis of the converged ephemeris. This concludes the output of a typical PLOD II run.

E. Flow Charts for PLOD II

The program PLODMN is the primary directing and controlling program of PLOD II. It serves to control input, output, and the order in which the subroutines are called. All parameters will be set in PLODMN with the exception of a few convergence tolerances, and all subroutines except FORTSZ related subroutines will be called by PLODMN. The one exception is the subroutine STINKS, which is called at each step by the subroutine TSTOP, and which calls the subroutine SPHER.

The program PLODMN starts the integration and ends the integration. The flow charting will be in three major sections: the input and starting procedure of the integration (Fig. 1); the subroutine calls and the order in which they are executed (Fig. 2), and the convergence flow and tape writing and output control of PLODMN (Fig. 3). A supplement flow chart of TSTOP is shown in Fig. 4. The flow charts are not complete, and are intended only to give the user an idea of the flow of the program PLOD II.

Figure 5 is a complete flow chart of the subroutine FORTSZ.

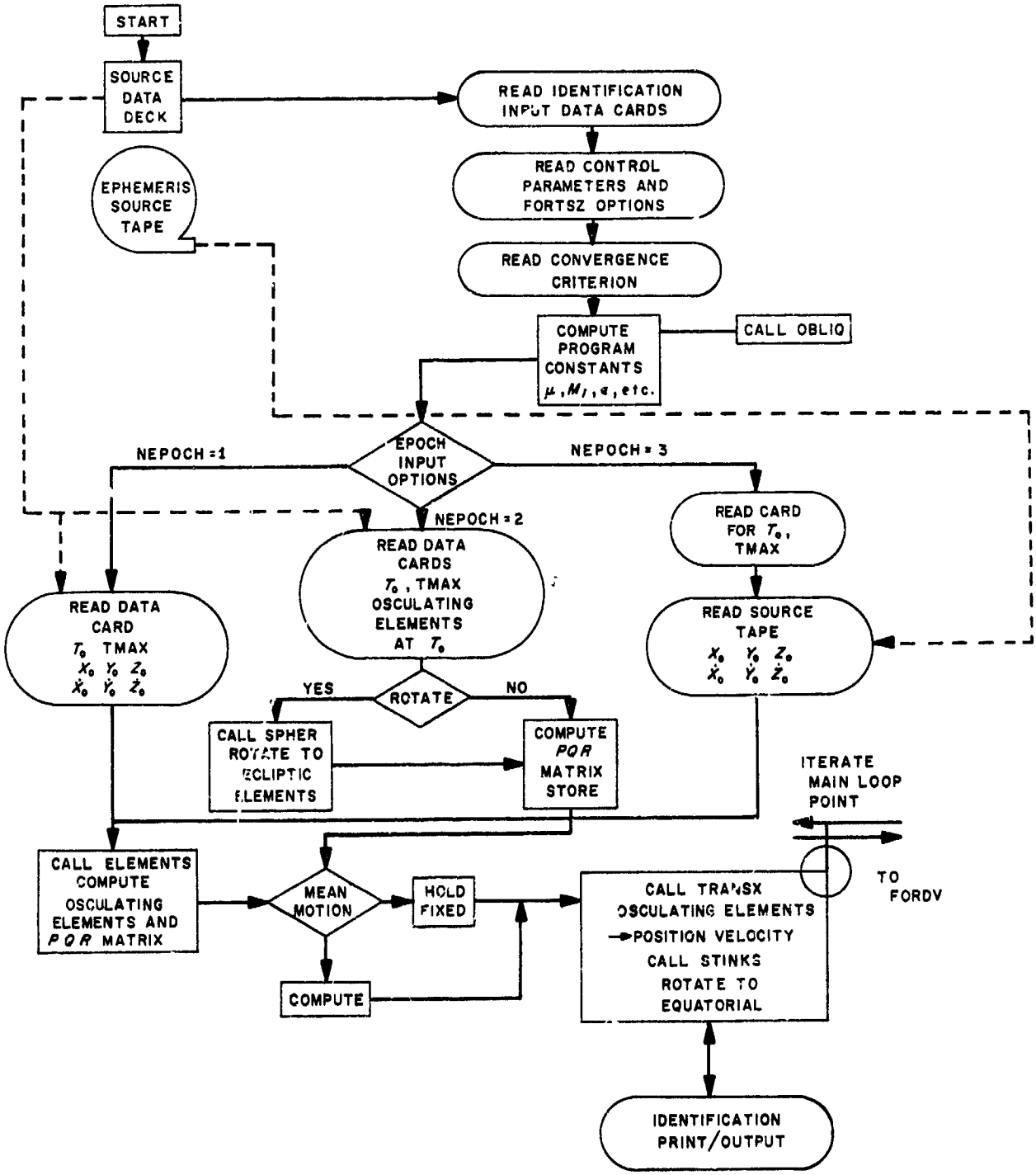


Fig. 1. Program PLODMN input and starting procedure

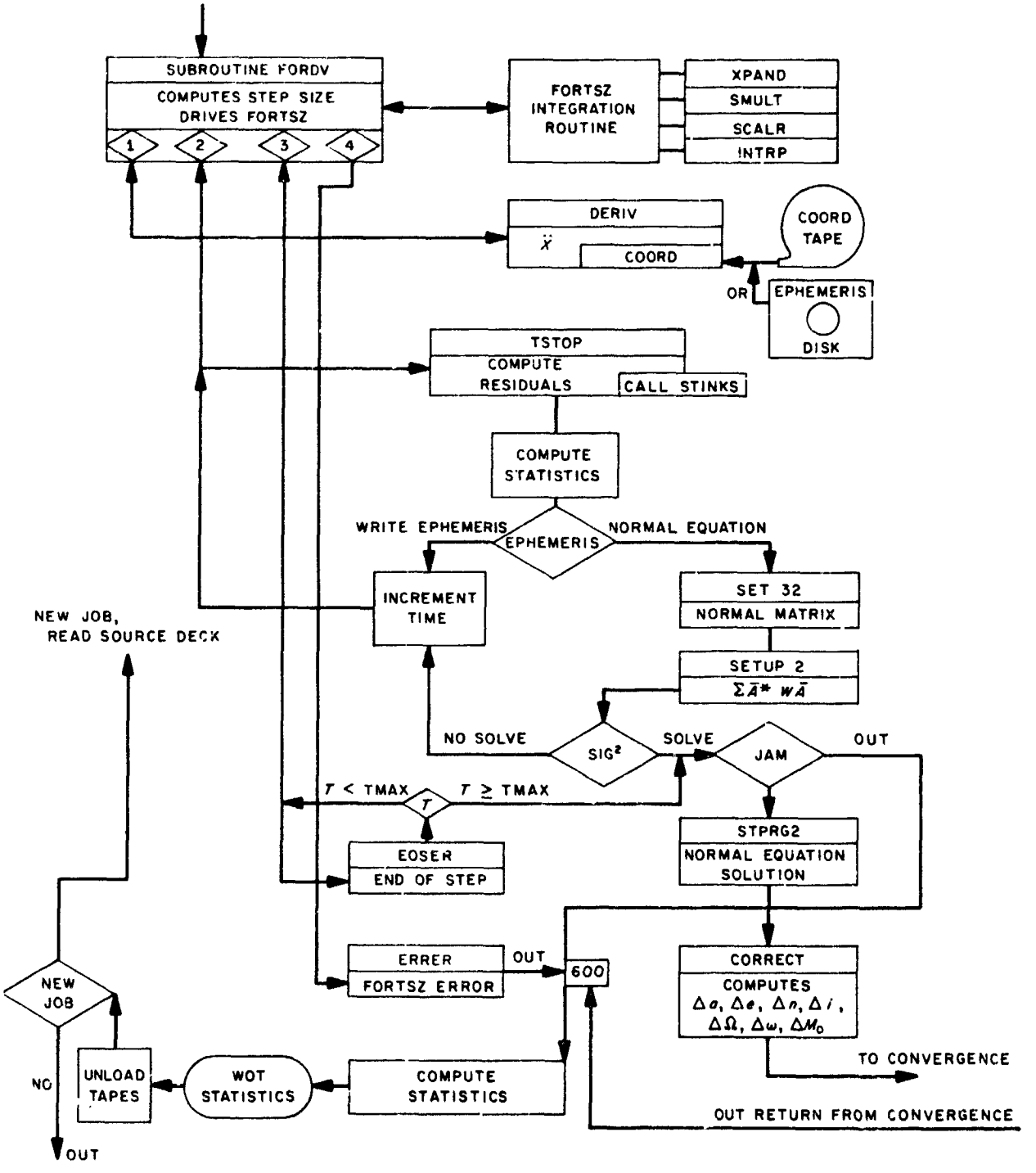


Fig. 2. Program PLODMN subroutine calling sequence

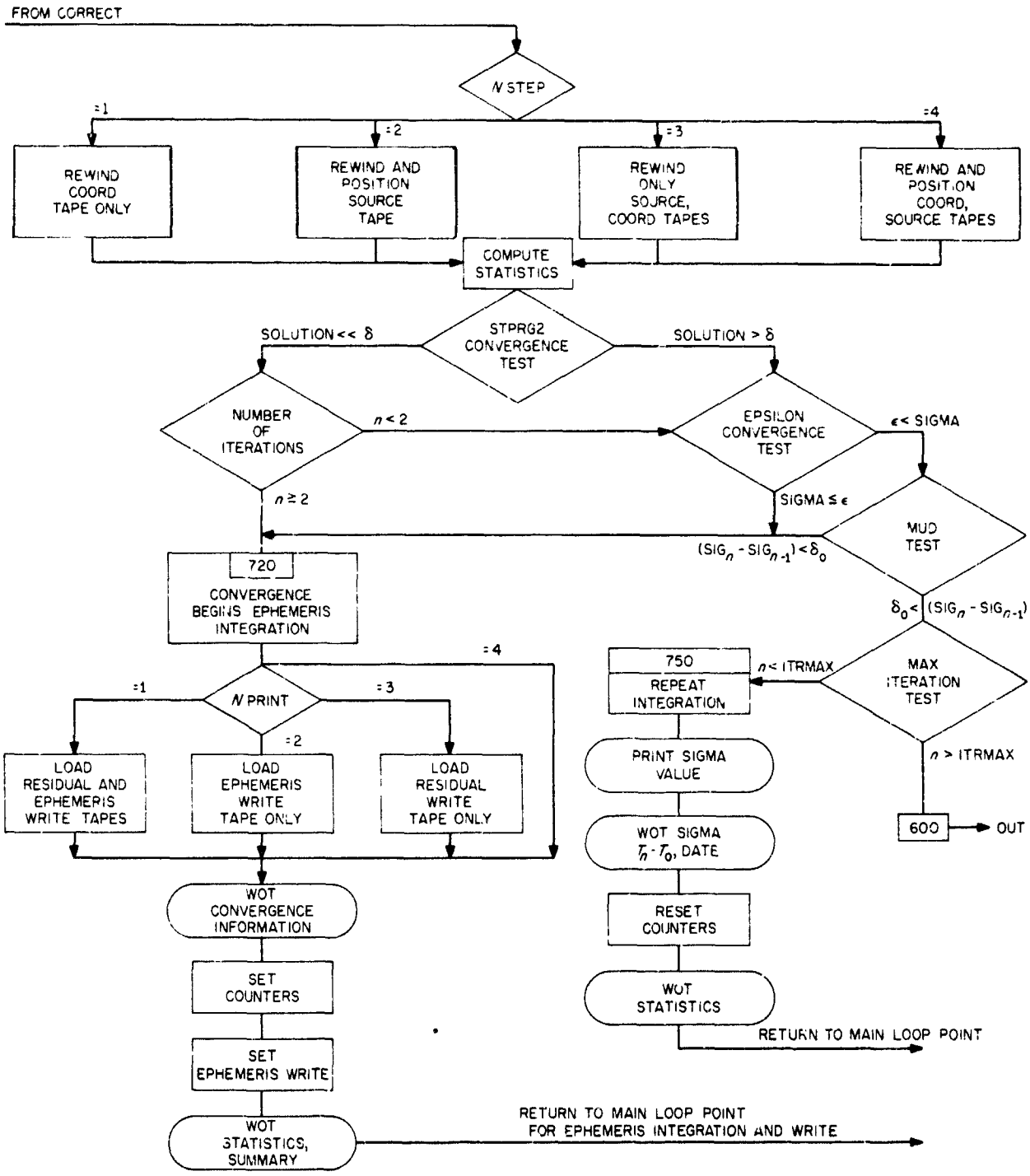


Fig. 3. Program PLODMN convergence and tape writing chart

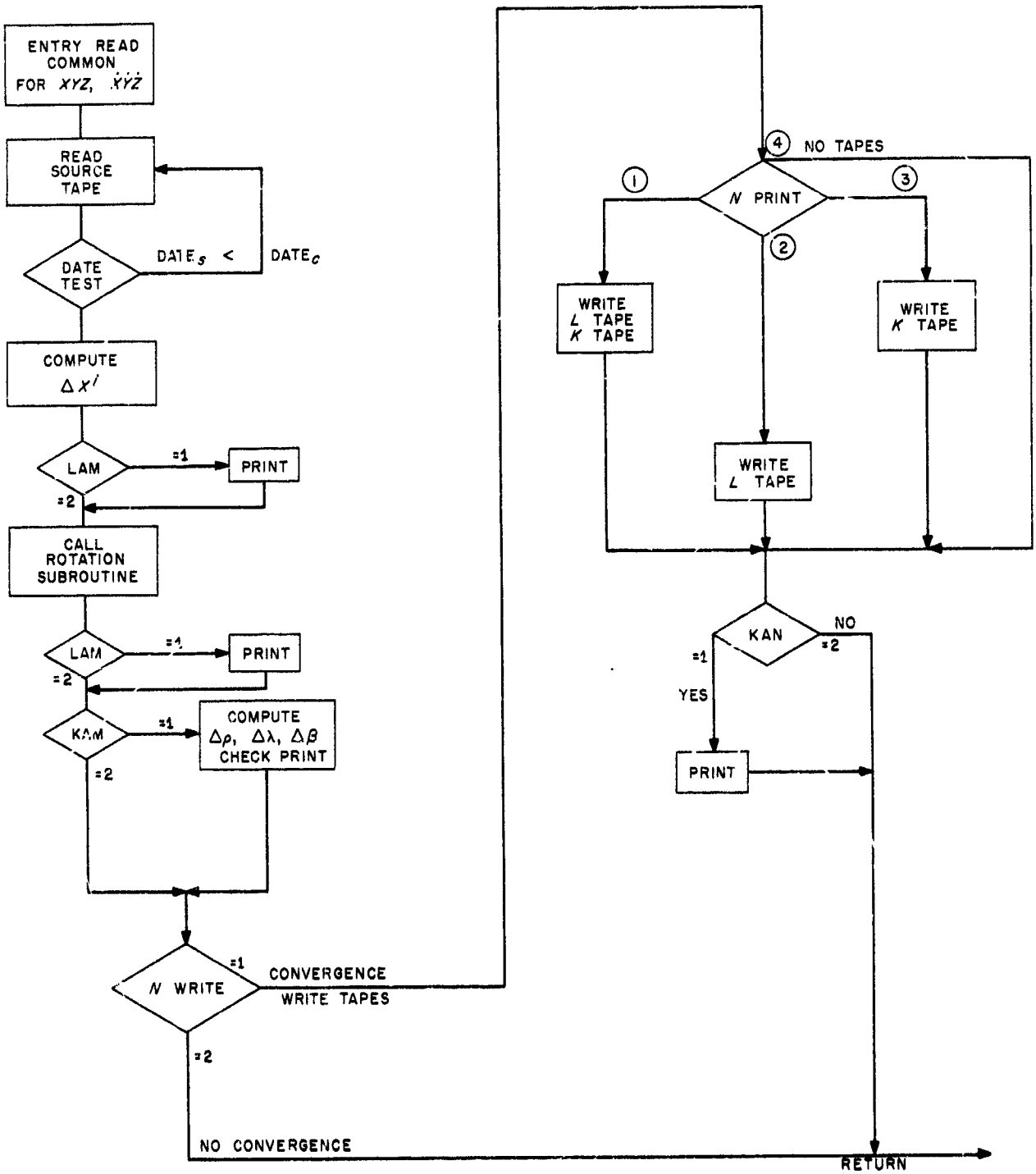


Fig. 4. Flow chart for subroutine TSTOP

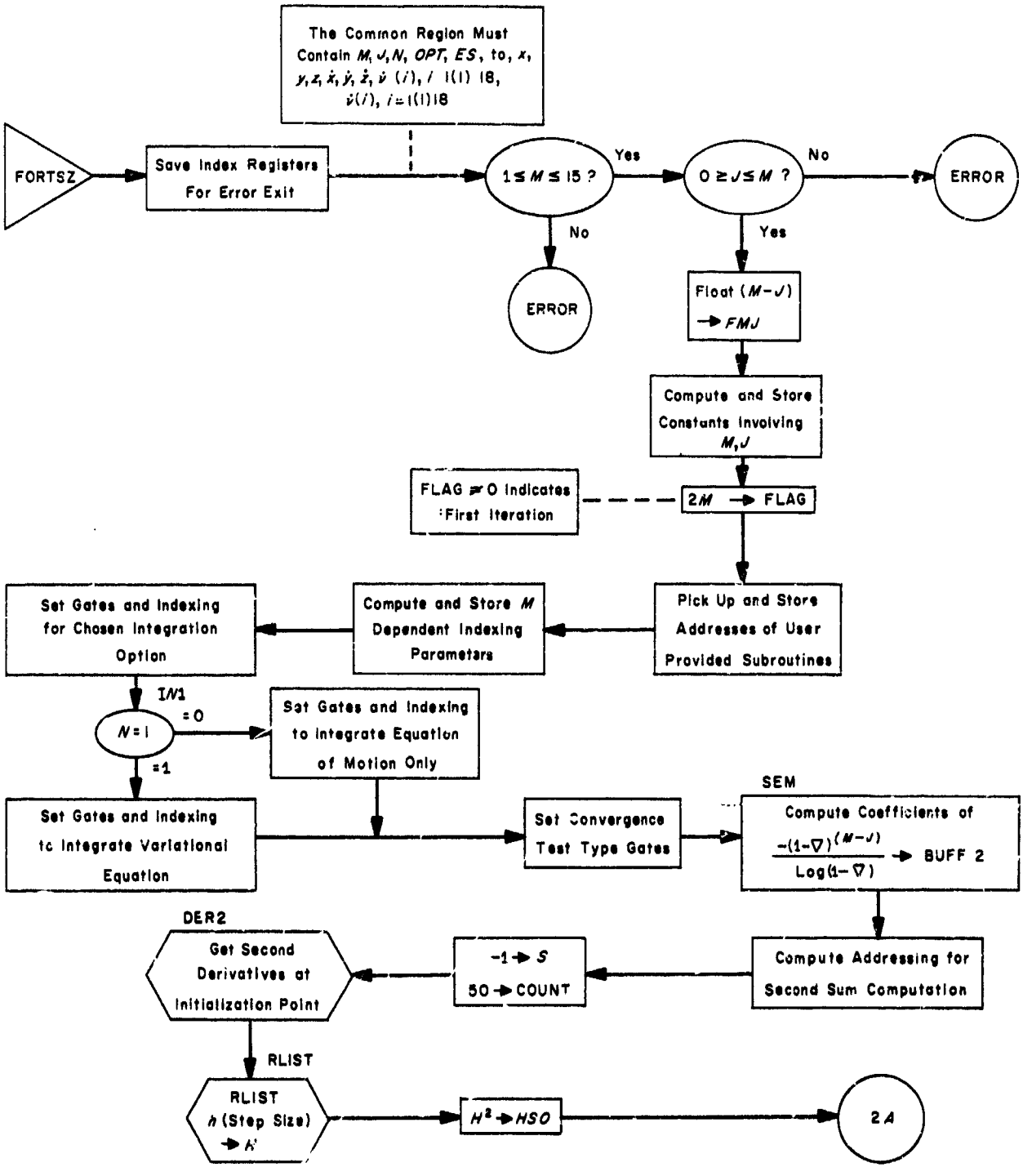


Fig. 5(a). Flow chart for subroutine FORTSZ

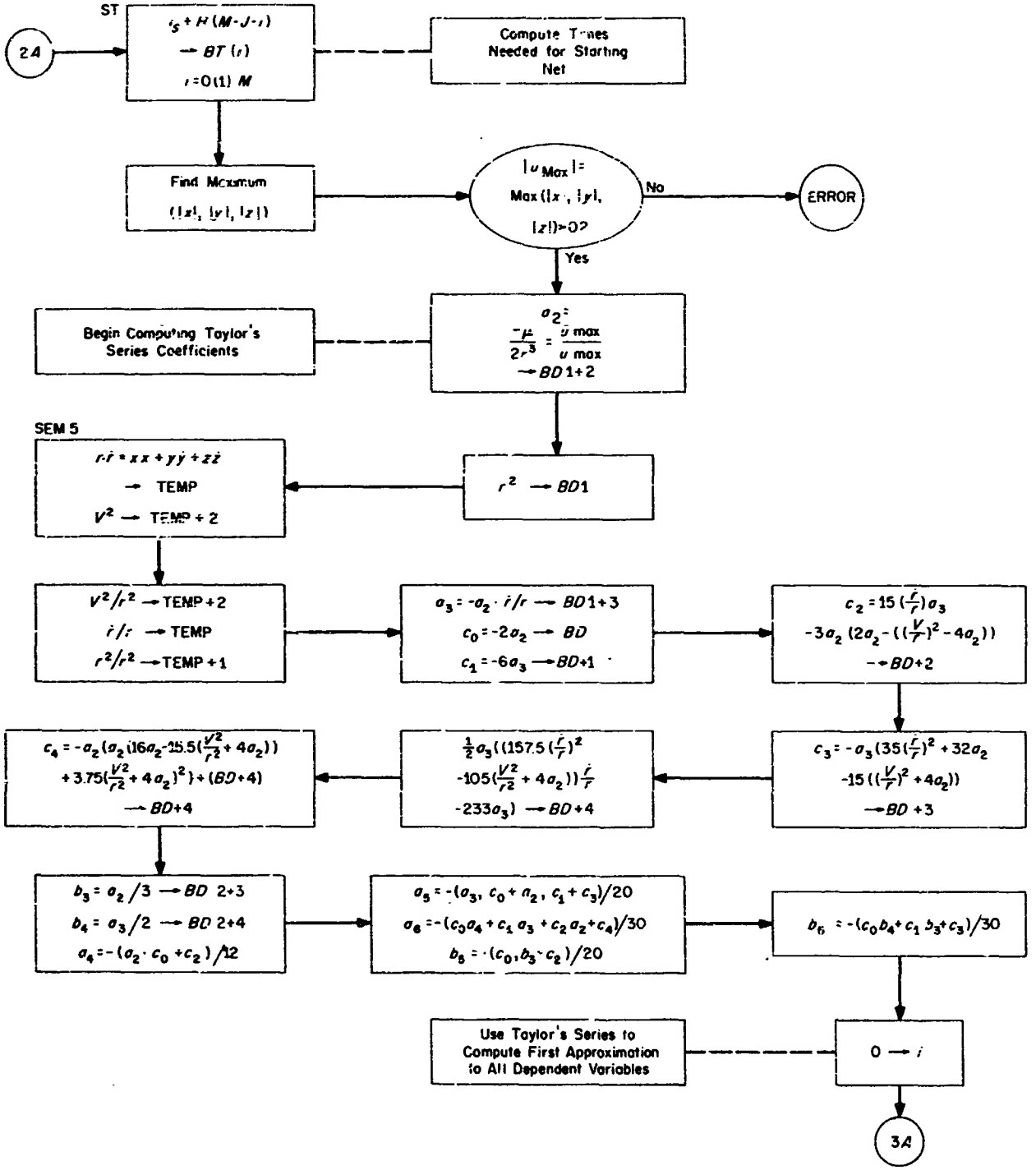


Fig. 5(b). Flow chart for subroutine FORTSZ

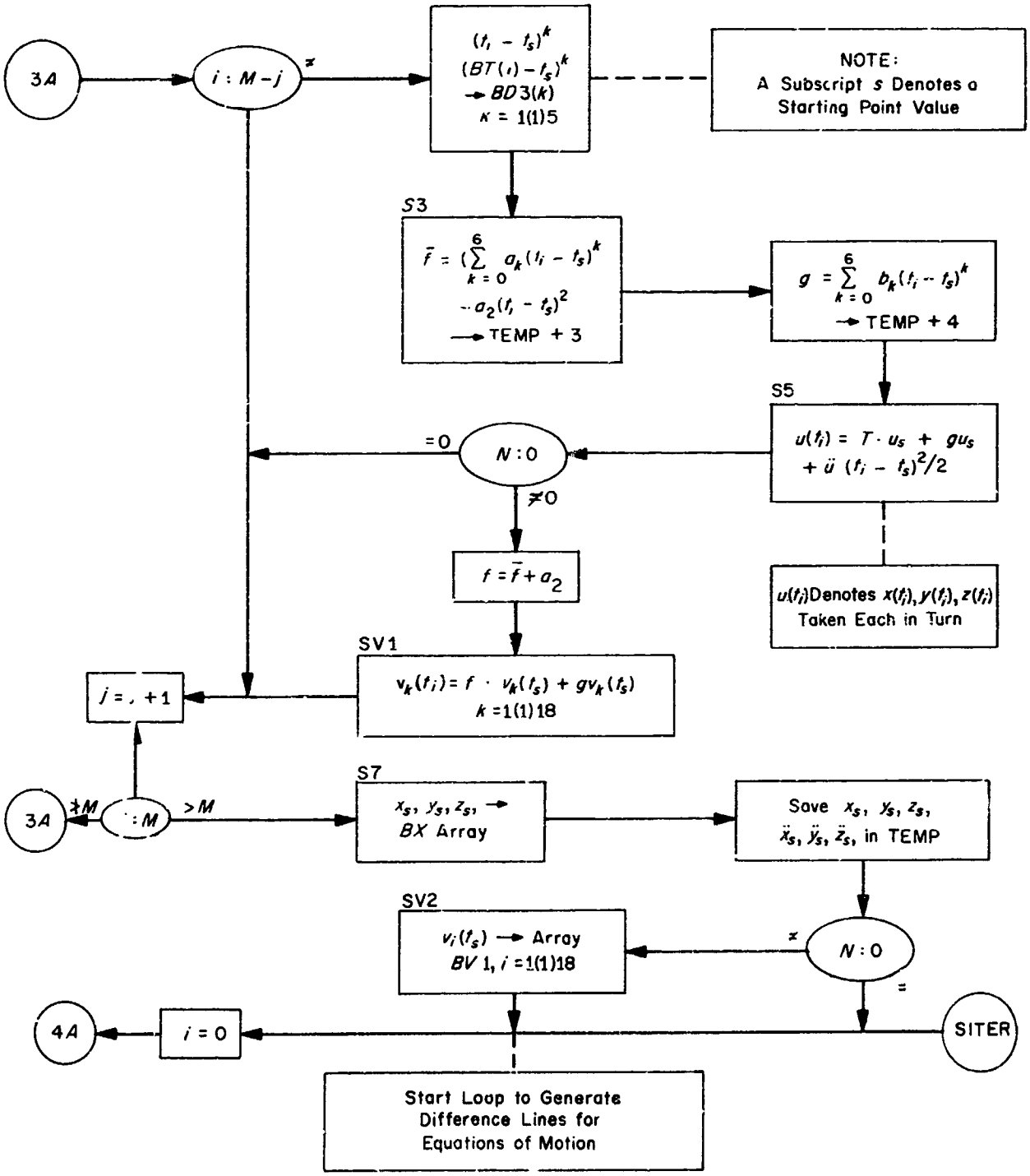


Fig. 5(c). Flow chart for subroutine FORTSZ

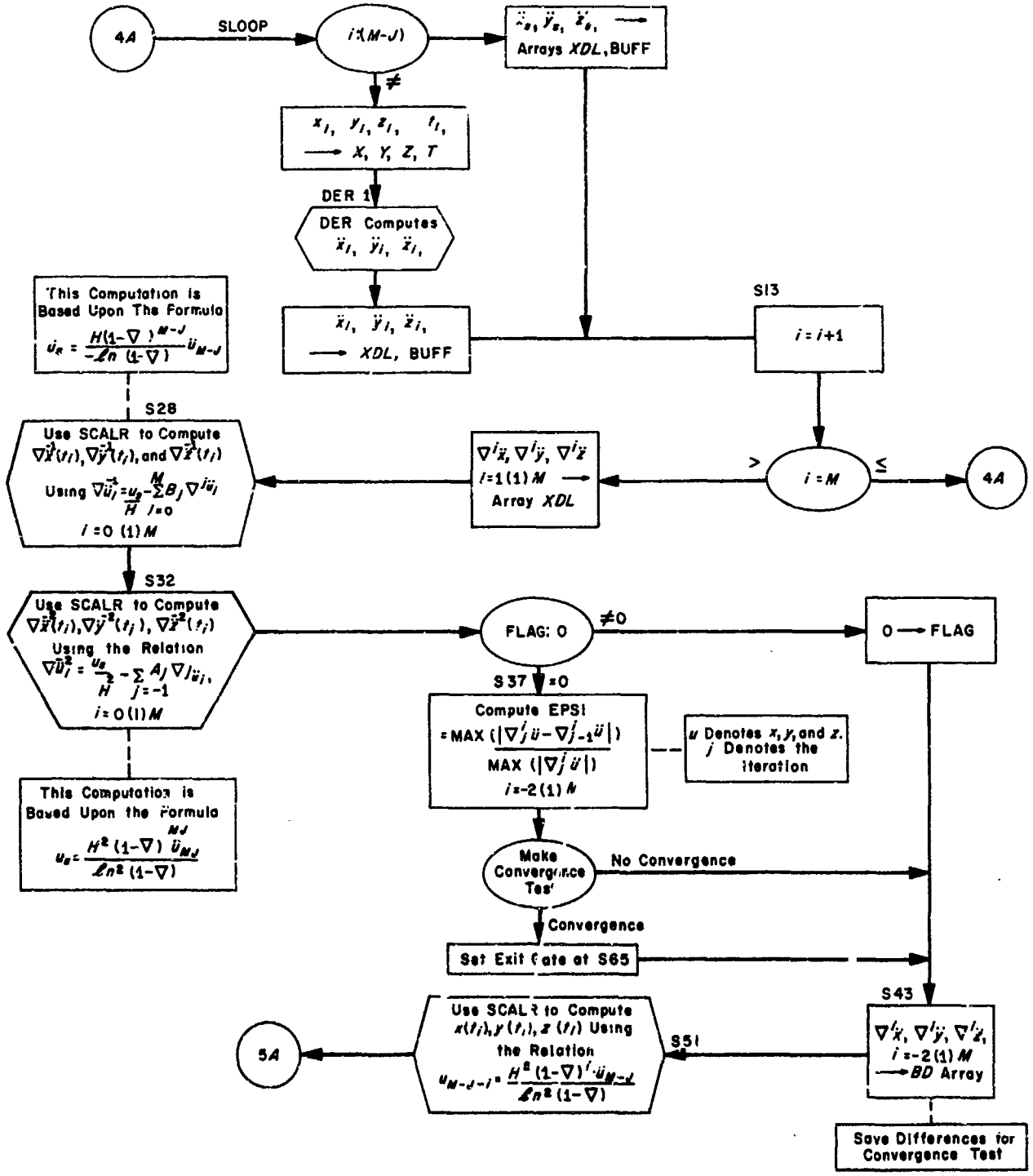


Fig. 5(d). Flow chart for subroutine FORTSZ

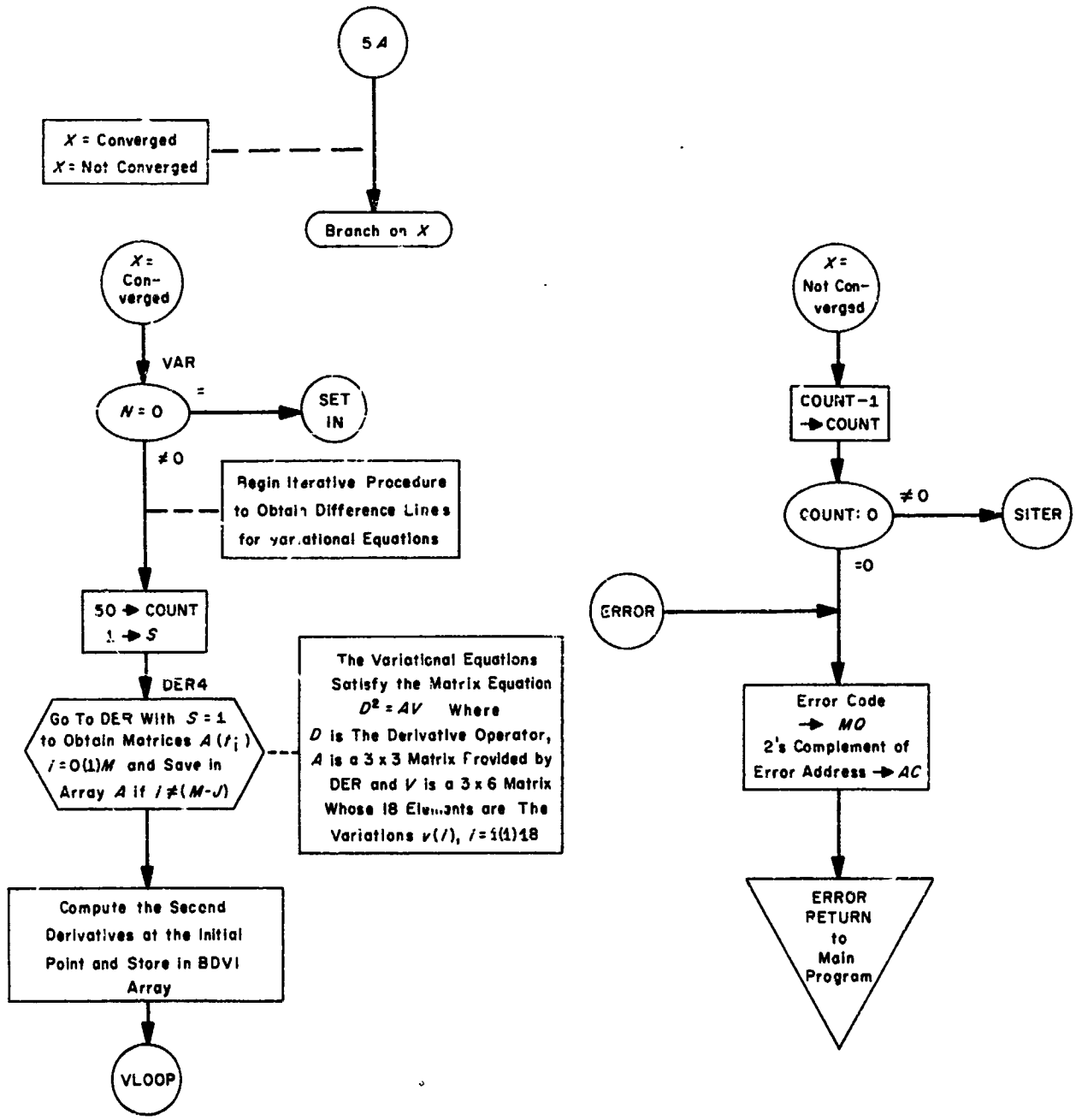


Fig. 5(e). Flow chart for subroutine FORTSZ

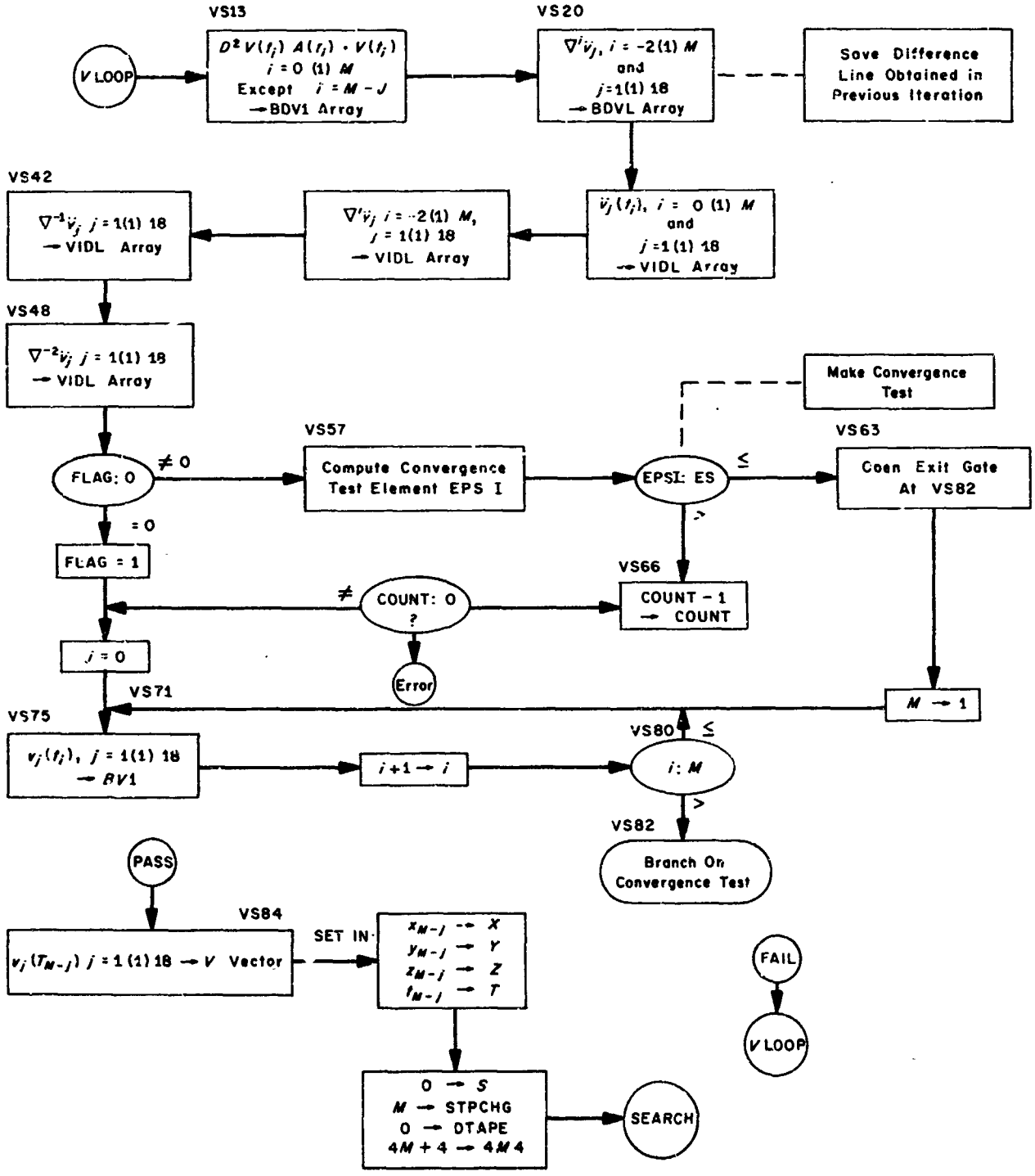


Fig. 5(f). Flow chart for subroutine FORTSZ

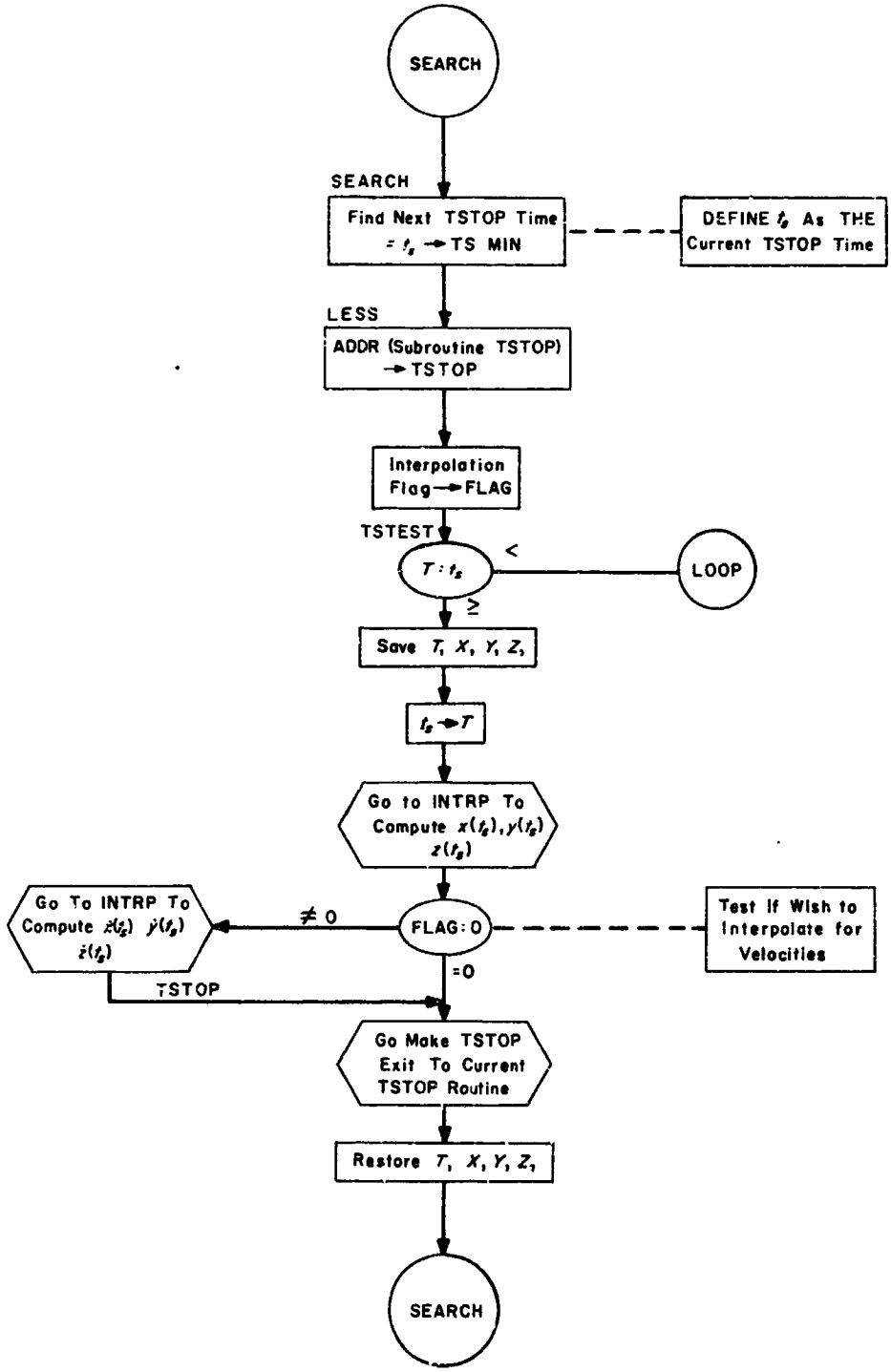


Fig. 5(g). Flow chart for subroutine FORTSZ

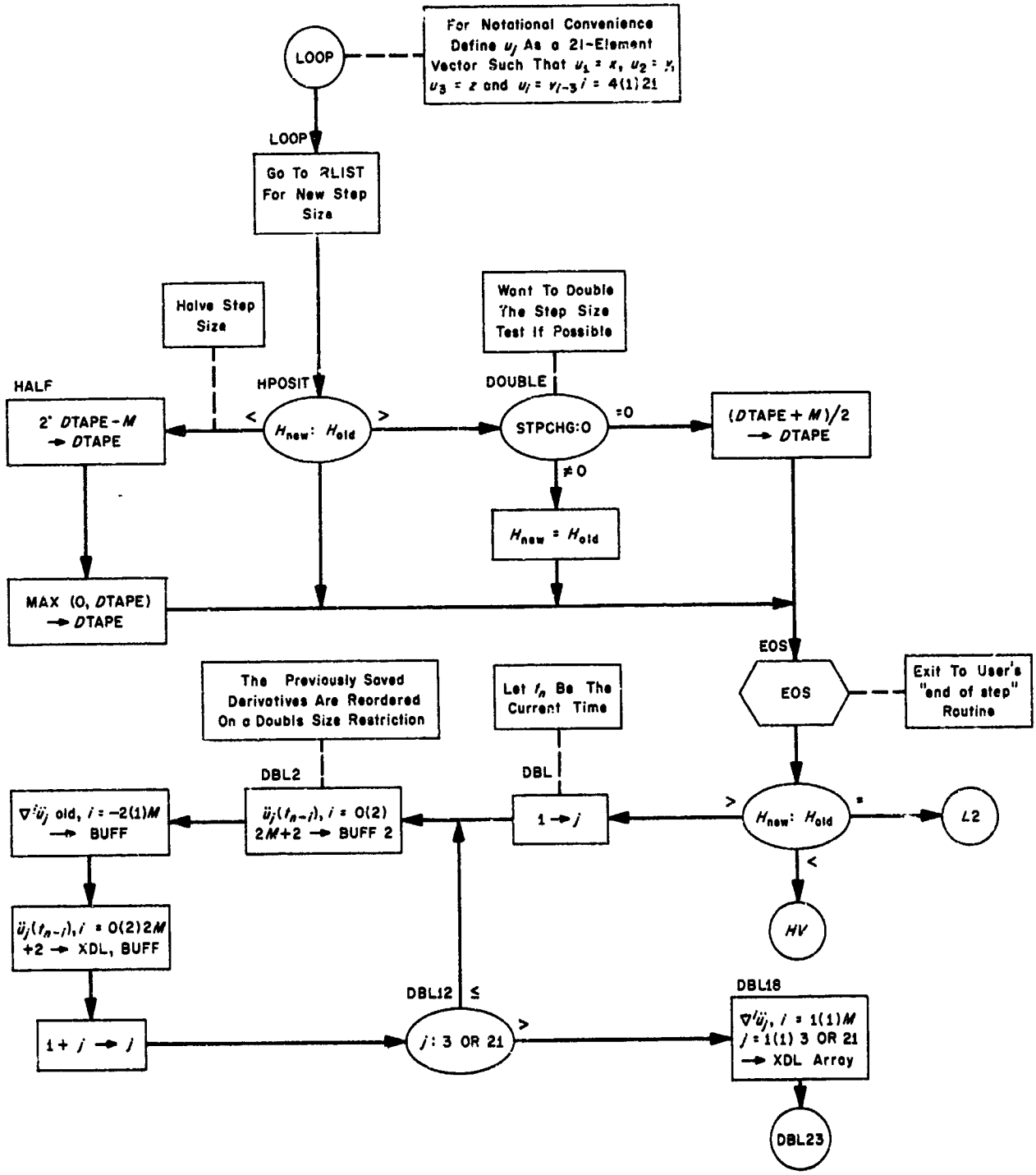


Fig. 5(h). Flow chart for subroutine FORTSZ

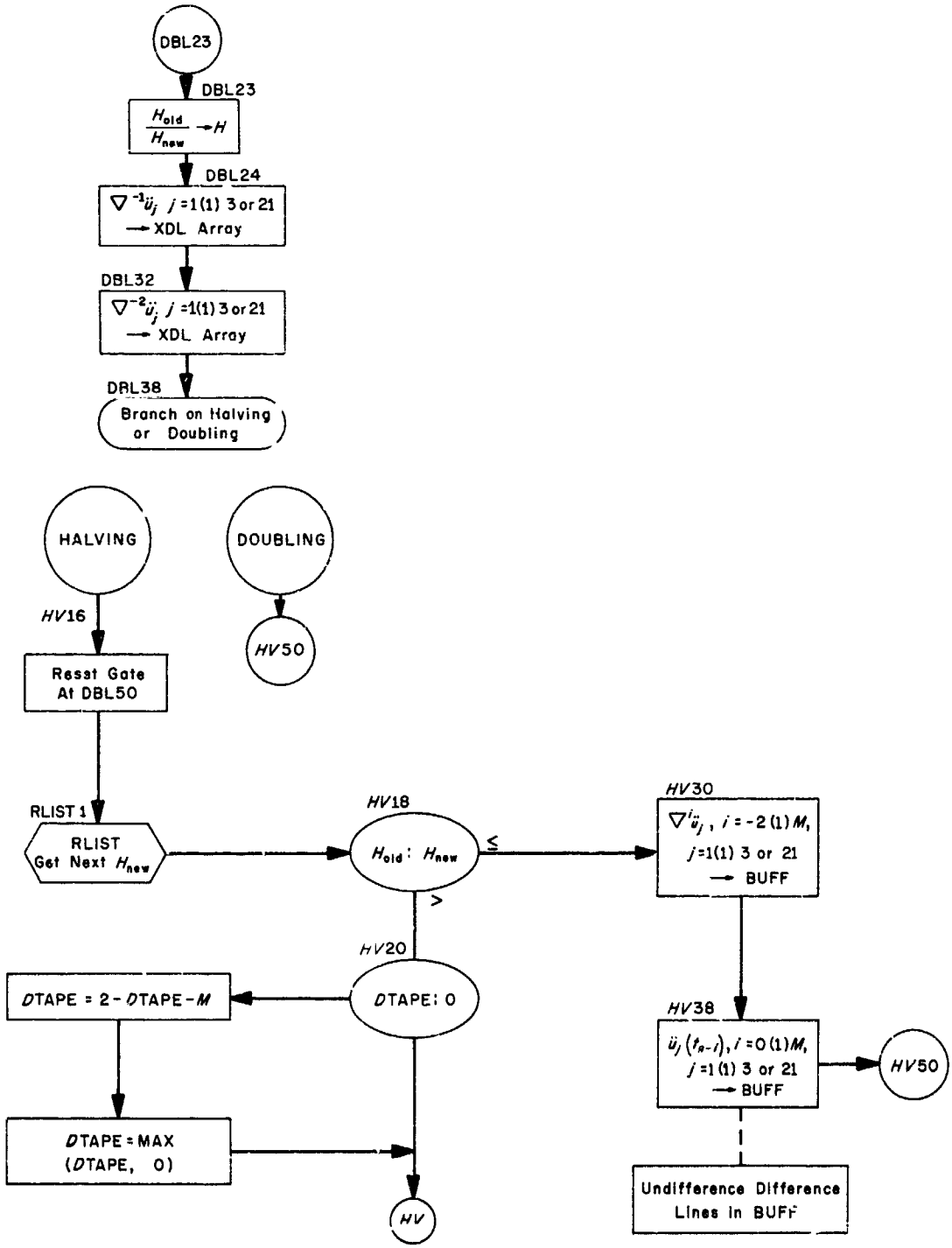


Fig. 5(i). Flow chart for subroutine FORTSZ

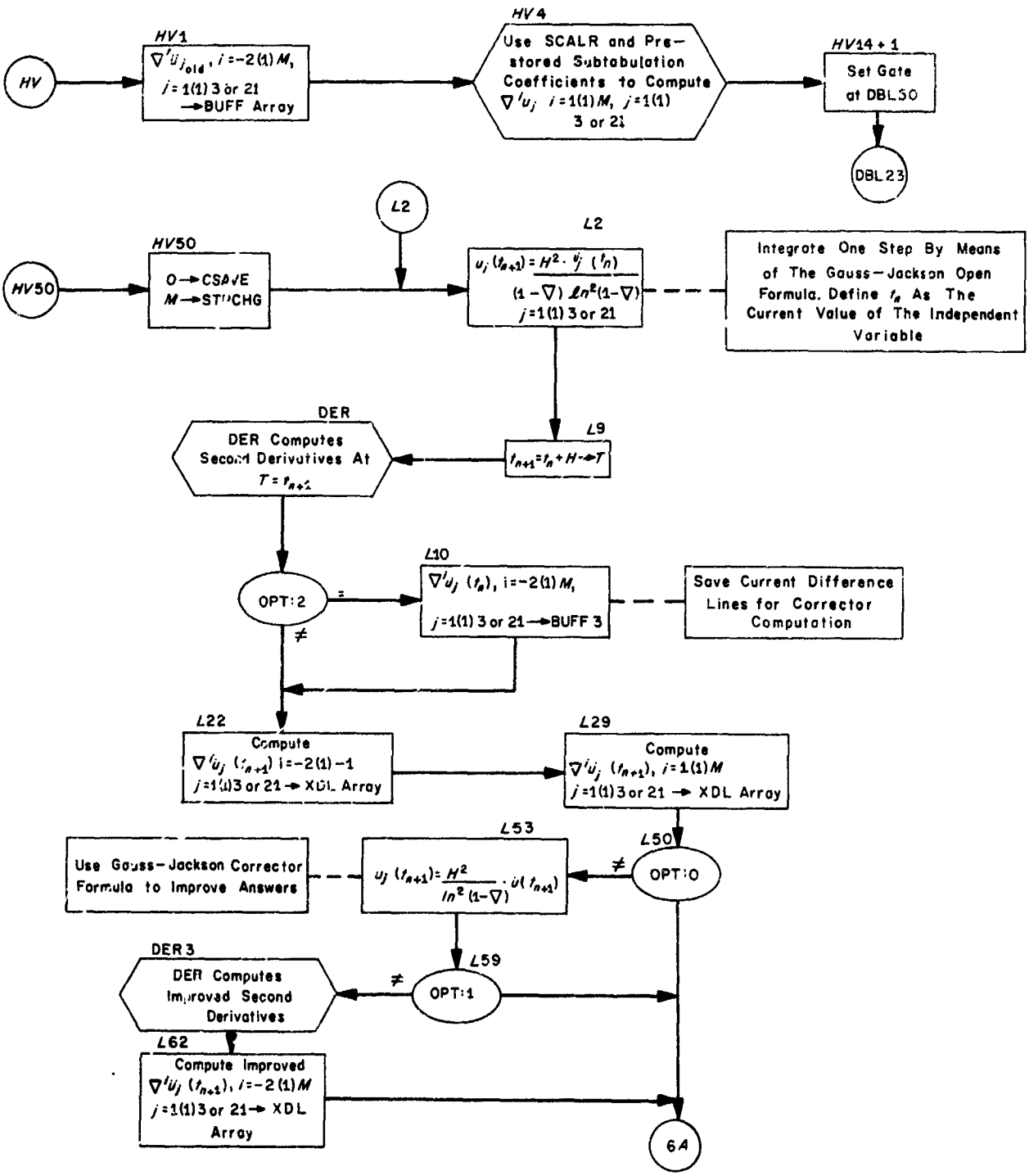


Fig. 5(j). Flow chart for subroutine FORTSZ

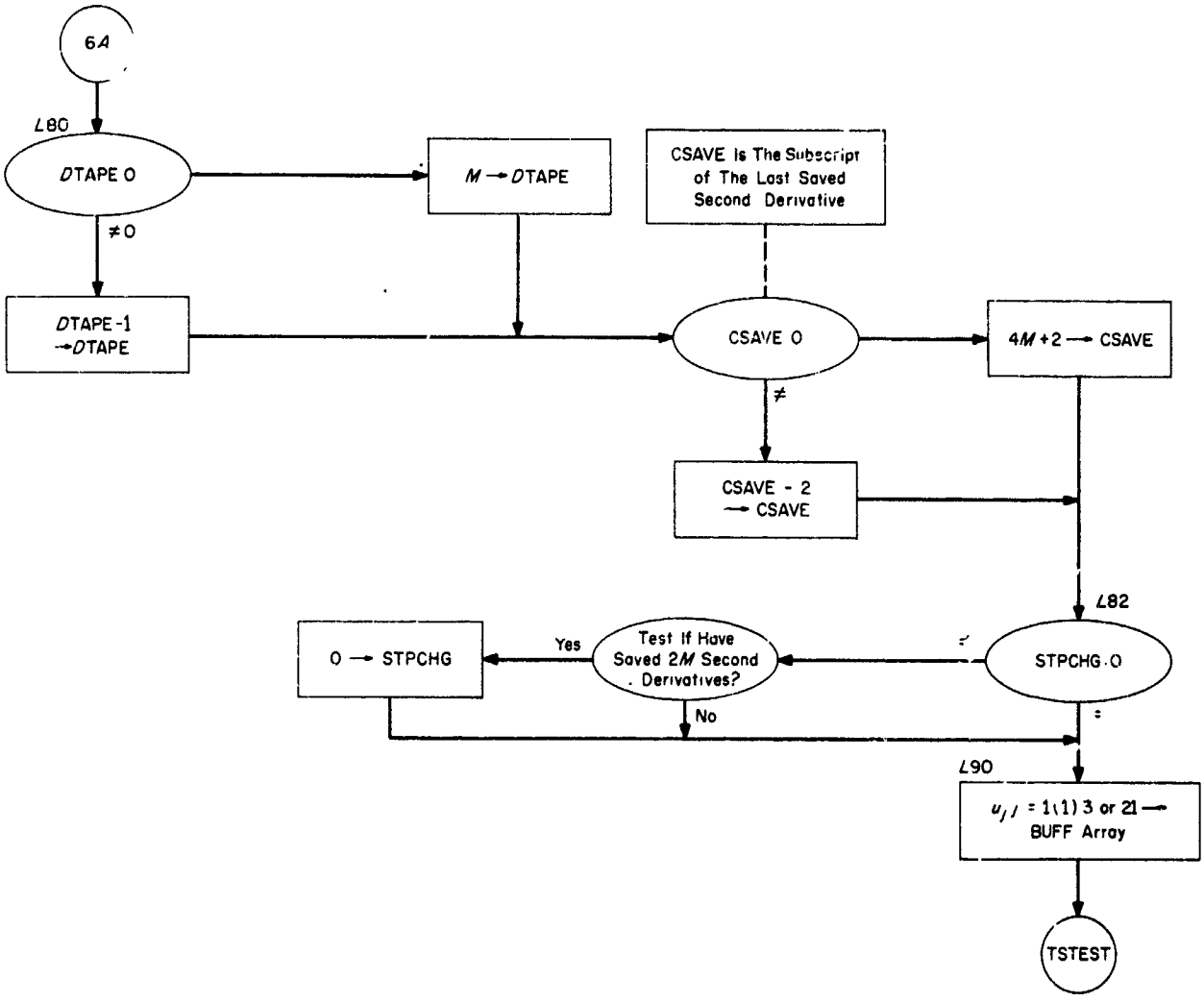


Fig. 5(k). Flow chart for subroutine FORTSZ

F. Main Program and Subroutine Descriptions

PLODMN is the main controlling program of PLOD II, while the main integration routine is FORTSZ. FORTSZ, with its related subroutines XPAND, SMULT, SCALR, and INTRP for PLOD II has been modified for the IBM 7094. That is, DPARTH and the macros for the 7090 versions are no longer used.

1. PLODMN

Multiple precision driver for the special perturbative integration technique. C. J. Devine, JPL

Machine: IBM 7090/94, Language: Fortran II

a. Purpose.

PLODMN serves as an input/output program and driver for the subroutines used by PLOD II. The program computes the needed constants for the integration procedure, controls the subroutine execution order, tests for convergence and number of iterations, and controls the input/output. PLODMN is the primary logical framework or outline of the integration procedure and calls the subroutines for special computation when needed. All of the major computation on the ephemeris integration is done in subroutines called by PLODMN.

b. Method.

The method of PLODMN is essentially that of PLOD II, and is described in the general outline of PLOD II.

c. Usage.

Given an ephemeris of a body to be integrated and a source tape of perturbing bodies (generally the other eight planets) PLODMN reads the orbit input information and starts an integration by calling appropriate subroutines. It is to be used with an input deck (described earlier) and the other general programs that make up PLOD II, which are described below.

d. Remarks.

PLODMN is the logic of PLOD II and was designed so that if there is a future need to change the control of PLOD II it can be done easily. Similarly, if there is a need to change the method of computation of PLOD II, this may be done in the subroutines called by PLODMN, and thus leave the logic of PLOD II untouched. The above description of PLODMN is necessarily brief, since all of PLODMN is essentially outlined in detail in the flow charts and description of PLOD II. PLOD II is defined as PLODMN and its related subroutines.

e. Subroutines required.

FORTSZ	The Gauss-Jackson DP equations of motion integration routine.
XPAND	The DP coefficient generator for FORTSZ.
SMULT	The DP series multiplier for FORTSZ.
SCALR	The DP inner product routine for FORTSZ.
INTRP	The DP interpolation routine for FORTSZ.
TSTOP	The DP residual computation and ephemeris printing routine.
STINKS	The DP system increments rotation routine.
SET32	The DP routine which computes the matrix of partial derivatives.
SETUP2	The DP accumulation of normal equations routine.
CORECT	The DP routine which corrects the osculating elements
TRANSX	The DP transformation routine from elements to rectangular coordinates.
DERIV	The DP acceleration routine.
EOSER	The end of step routine.
ERRER	The error routine called by FORTSZ.
FORDV	The communication routine for PLODMN and FORTSZ.
STPRG2	The DP stepwise solution of normal equations routine.
ELEMTS	The DP transformation routine from rectangular coordinates to elements $a, n, e, i, \Omega, \omega, l$.
OBLIQ	The DP routine which computes the obliquity given the Julian date
SPHER	The DP routine used to compute latitude, longitude and ρ, given rectangular coordinates.
ARCTN	The DP arctangent routine, used as a driver for FORTRAN library subroutine.
RUN	Rewind and unload tape routine.
DOUTPT	The DP output routine (library tape).
DPINPT	The DP input routine (library tape).
DCOS, DSIN, DSQRT	Fortran library routines.

f. Storage.

All computable quantities are stored in DP. The program communicates with FORTSZ through common storage, and the description of this storage may be found in the following Section. The main quantities communicated by PLODMN in common between its subroutines and FORTSZ are time, integration step size, and position and velocity coordinates

2. FORTSZ

Gauss-Jackson DP equations of motion integration routine. J. H. Beeman, Computer Sciences Corporation, August 1, 1962

Machine: IBM 7090/94 FAP

a. Purpose.

FORTSZ is a closed subroutine designed to solve the equations of motion (in rectangular coordinates) of a body in a gravitational field, and, if desired, to calculate the first-order variational coefficients of the computed

trajectory. The integration is accomplished by either the Gauss-Jackson open formula or by utilizing the open formula as a predictor and then applying its closed counterpart as a corrector. The formulas are in terms of backward differences. The order of the differences employed is optional within the limits $1 \leq$ order of the highest retained difference ≤ 15. The routine employs 7094 compatible DP, and is intended for computation with the IBM 7094 as well as the 7090. Provision has been made for interrupting the computation at prespecified values of the independent variable, as well as after each step.

b. Restrictions.

1. FORTSZ will not integrate backward in the independent variable (the step must be positive).
2. Change of step size is limited to doubling or to halving.
3. Underflow and overflow are not checked internally.
4. The user must provide the desired interruption subroutines, a program to compute the desired step size, and a derivative subroutine to compute the second derivatives of the equations of motion (and of the variational equations, if required).
5. FORTSZ is a FAP coded subroutine which is *not* Fortran compatible.
6. FORTSZ is intended for use with the IBM 7090 and, with minor modification, the IBM 7094.
7. The class of differential systems this program will solve is limited in four basic respects. First, the Gauss-Jackson equations are valid only for systems of second-order differential equations in which the first derivative term is absent The second limitation concerns the starting procedure. A single precision, modified Taylor series solution to the two-body problem is employed to obtain a first guess to commence an iterative procedure for obtaining DP difference lines. If the solution of a set of equations in the region of the initial conditions is not "sufficiently close" to that of the two-body problem, the starting procedure will not converge. A third restriction is that only three primary and 18 secondary differential equations may be solved by this routine. Finally, the three primary equations may not involve the secondary variables. The restrictions contained in this paragraph will have little meaning for the user as long as this program's application is limited to the problem area for which it was designed.

c. Method.

A Gauss-Jackson procedure is employed to accomplish the integration*. Step size is controlled by a user-coded subroutine, but step size changes must be limited to doubling and halving. The following options are available to the user:

1. Integration method.

   Gauss-Jackson open formula.

   Gauss-Jackson open formula and improvement of the coordinates by one application of the Gauss-Jackson closed formula (note that no improvement to the difference lines is accomplished).

   Gauss-Jackson oper formula as a predictor and the Gauss-Jackson closed formula as a one-cycle corrector to improve both the coordinates and the difference lines. A more detailed description of the numerical procedures is contained in the Section devoted to formulas.

2. Order of integration procedure.

   The order of the differences to be used may be specified by the user between the limits of $1 \leq M \leq 15$, where M is the highest difference retained in the calculation.

3. Starting procedure.

   If Mth differences have been chosen by the user, then the starting procedure must generate a net of $M + 1$ points by utilizing the given initial position and the differential equations. The location of the initial position in this net may be controlled by the user to maximize the accuracy of the starting procedure.

   All calculations are performed in IBM 7094 compatible DP. The DP is accomplished in the 7090 version by a special set of macros which simulate 7094 DP instructions coupled with a DP arithmetic subroutine.

d. Usage.

1. It is expected that this program will be embedded in a system of the following general character: A "driver" will call FORTSZ. Control will return to that program only if an error condition occurs. Prior to integrating each step, FORTSZ will surrender

*Jackson, J., "Note on the Numerical Integration of $d^2x/dt^2 = f(x,t)$," Royal Astronomical Astronomy Society Monthly Notices, Vol. 84, pp. 602-606, 1924.

control, first to one of a set of subroutines described below as T stops, and next to a user subroutine called the "end of step" program. The first transfer is made only at prespecified values of the independent variable, while the second transfer is made each time a step is completed. In this manner, the user is allowed to make use of the results of the integration in several ways if he so desires.

2. All numerical data used by this program are expected to be in FORTRAN IV compatible form. This means that arrays are forward stored, that the low-order part of a DP word is stored directly above its high-order part, and that fixed-point quantities are expected as full-word integers.

3. The quantities M, J, N, OPT, ES, T, X, Y, Z, XD, YD, and ZD must be stored in the communication region prior to execution of FORTSZ. A detailed description of the form and meaning of these quantities is contained in Section 5.

   If $N = 1$; i.e., if the variational coefficients are to be computed, the user must also supply initial conditions for these coefficients. Thus if $N = 1$, the user must also initialize the storage vectors V and VD. It is noted that once FORTSZ has been entered, the user may not change any of these parameters without restarting the integration routine.

4. Calling sequence:

```
CALL FORTSZ or TSX $FORTSZ, 4
PZE     DER, , EOS
PZE     RLIST
TRA     ERROR
PZE     TSTOP1, F1, TS1
PZE     TSTOP2, F2, TS2
.....
PZE     TSTOPN, FN, TSN
PZE     0
```

where the symbols are defined as follows:

DER — The entry point address of the user subroutine to compute the second derivatives of the dependent variables x, y, and z (and those of the variational coefficients $v(i), i = 1(1)18$, if $N = 1$). This subroutine must compute these quantities from the data in T, X, Y, and Z (and $V(i), i = 1(1)18$, if $N = 1$). The computed values of these derivatives must be stored in locations XDD, YDD, and ZDD (and VDD (i), $i = 1(1)18$, if $N = 1$). In the event $N = 1$, the following convention is to be observed. If $S = -1$ (see Section 5 for location), then DER need compute and store only the second derivatives of the positional variables. If $S = +1$, DER must store the elements of the matrix denoted as the A matrix (in the later Section entitled "Variational Equations Starting Relations") in the communication region array MATRIX. If $S = 0$, DER must compute and store both the positional and variational second derivatives in XDD, YDD, ZDD, and VDD (i), $i = 1(1)18$. Whenever $S \neq 1$ ($S = 1$ only while generating the initial variational difference lines), the array MATRIX may be viewed as temporary storage allocated to the subroutine DER.

EOS — The entry point address of the user's "end of step" routine. This program is called after each full integration step in order to return control to the user. See the discussion of DTAPE in Section 5.

RLIST — The entry point address of the user step size control routine. The program must leave the desired DP step size in the AC and MQ each time it is called. The most significant part of the step size is to be placed in the AC. The step size currently being used by FORTSZ (except for the first entry after execution) may be found in location H. Step size may be changed by halving or doubling the current step size only. If the step size is changed, FORTSZ will be unable to double the step size within the next M steps. Repeated halving is permissible. FORTSZ will continue to halve the step size, without advancing the calculation, until RLIST no longer signals a desire to reduce the interval.

NOTE: FORTSZ will not detect an attempt to change step size to some interval other than twice

or half the current step. If the user's RLIST routine makes such a step size change, an undetected error will result.

ERROR The address to which the user wishes control transferred if an error condition occurs in FORSTZ. The return from FORTSZ will be TRA 3, 4 with the 2's complement of the location at which the error condition was detected in the accumulator and a fixed point error code number in the MQ. The error code is as follows:

Error code	Error condition
1	$X = Y = Z = 0$ are illegal initial conditions.
2	Either M or J is out of bounds. $1 \leq M \leq 15$ or $0 \leq J \leq M$
3	The starting procedure for the equations of motion failed to find a difference line which satisfies the convergence test specified by ES in 50 iterations.
4	Same as 3 except applies to variational equations.
5	Illegal T stop time. INTRP will not allow extrapolation.

The final strings of locations in the calling sequence are all of the form PZE TSTOP, F, TS and are defined as triggers. These triggers are the linkage controls to user subroutines which allow the user to take action at a preset value of the independent variable. These triggers are also known as T stops. The triggers each state that control is to be transferred to location TSTOP when the independent variable equals T_s, the DP contents of address TS. If $F = 0$, FORTSZ will compute the values of the coordinates x, y, and z corresponding to T_s and store them in X, Y, and Z prior to the transfer. If $F = 1$, FORTSZ will also compute x, y, and z and store these quantities in XD, YD, and ZD. T will be set to T_s in either case. No procedure is available to provide intermediate values of the variational coefficients.

The logic used to execute the T stops is as follows:

Let $t_{s1}, t_{s2}, t_{s3}, \cdots, t_{sk}$ be a set of values of the independent variable for which interruptions are desired. FORTSZ sets $t_m = \min(t_{s1}, t_{s2}, \cdots, t_{sk})$. Integration continues until the independent variable, t_n, reaches a value such that

$$t_{n-1} < t_m \leq t_n$$

The value of t_m is placed in T. The subroutine INTRP is then used to obtain the values of the coordinates (and the velocities, if $F = 1$) at t_m. Control is then transferred to address TSTOP. After control is returned from the user's interruption routine, the values of X, Y, Z, and T are restored to the values corresponding to t_n and the next value of t_m is determined as before.

Comments on triggers.

a. Any number of triggers may be employed. The variable length list is terminated by PZE 0.

b. Whenever a T stop interrupt subroutine is executed, it must update the corresponding time, T_s, or inactivate the trigger to avoid an obvious logical loop. A trigger may be inactivated by changing the PZE to an MZE. A negative sign bit signals that a trigger is to be ignored when scanning the list of T stops.

c. INTRP does not allow extrapolation. Let t_0 be the initial value of the independent variable. If J is defined as in the next section, and if the value of any T stop, T_s, is such that

$$t_{-J} > T_s,$$

an error return will result as soon as initialization has been completed. Similarly, if the T stop values are being updated, an error will result if any T stop is recomputed so that it takes a new value smaller than $t - M^*H$, where t is the current value of the independent variable.

NOTE: The linkage to all user subroutines is
TSX SUBROUTINE, 4.
Return is expected to be of the form
TRA 1, 4

5. Communications region.

The communication region is an absolutely located storage block established for the exchange of data between FORTSZ and the user's routines. All

parameters needed for the initialization (see Section 3) must be located in this block before control is transferred to FORTSZ. The status of each cell when either a T stop or an end-of-step exit occurs is indicated below. As the origin of this region is easily changed, the user must determine what absolute location is currently being employed for the definition of the program location COMMON.

Location	Program name	Description
COMMON	*M*	The fixed-point integer denoting the highest order of difference to be retained by the integration procedure in which $1 \leq M \leq 15$.
+1	*J*	The fixed-point integer controlling the location of the given initial coordinate in the net of positions generated by the starting procedure in which $0 \leq J \leq M$. $J = 0$ places the initialization point at the end of the net away from the direction of integration. $J = M$ places the initialization point at the position for which the backward difference lines are to be generated. Intermediate values of J position the given point between these extremes in an obvious manner.
+2	*N*	This fixed-point integer flags the user's choice in regard to the variational equations. $N = 0$ means integrate only the three positional differential equations. $N = 1$ means integrate both the positional and the variational differential equations.
+3	*OPT*	This fixed-point integer controls the integration method. $OPT = 0$ denotes Gauss-Jackson open method, $=1$ denotes Gauss-Jackson pseudo-predictor-corrector method, and $=2$ denotes Gauss-Jackson predictor-corrector method.
+	*DTAPE*	This cell is set by FORTSZ as a signal to the user's end-of-step routine If the user desires to save a covering set of difference lines, the end-of-step program must save all desired lines every time *D*TAPE = 0.
+5	*S*	This cell is set to a fixed-point integer by FORTSZ as a flag for the user's derivative routine (see Section 4).
+6	*ES*	The single-precision floating-point convergence test factor for the starting procedure (discussed in detail later). Note that *ES* may be either positive or negative, giving two types of convergence test. *ES* is used by both the positional and the variational equations.
+12	*H*	The DP floating-point value of the step size currently being employed by the integration procedure is located in *H*. This cell may not be altered by the user.
+14	*T*	Storage for the DP floating-point value of the independent variable. Initially it must contain the initialization value of this variable, t_0. At any later time, this cell will contain the current value of the independent variable corresponding to *X*, *Y*, and *Z*. This cell will correspond to the velocities located in *XD*, *YD*, and *ZD* initially, but thereafter only for a T stop with $F = 1$ (see Section 4). The value of this cell will correspond to the difference lines located in XDL and VDL for end-of-step exits.
+16, 18, 20	*X*, *Y*, *Z*	Storage for the DP floating-point values of the rectangular coordinates x, y, and z of the body whose trajectory is being computed. Initially, these cells must contain the x_c, y_0, and z_0 corresponding to t_0 in T. These cells always contain the coordinates which correspond to the value of t contained in T.

Location	Program name	Description
+22, 24, 26	*XD, YD, ZD*	Storage for the DP floating-point values of the velocities $\dot{x}$, $\dot{y}$, and $\dot{z}$ of the body. These cells must originally contain the $\dot{x}_0$, $\dot{y}_0$, and $\dot{z}_0$ corresponding to t_0. These cells are updated only if a T stop is executed with $F = 1$ (see Section 4).
+28, 30, 32	*XDD, YDD, ZDD*	Storage for the DP floating-point values of $\ddot{x}$, $\ddot{y}$, and $\ddot{z}$ which must be stored in these cells by the user's derivative subroutine as outlined in Section 4.
+34–68	*V*	Storage for the 18 DP floating-point values of the variational coefficients $v(i), i = 1(1)18$. These cells are unused if $N = 0$. Initially, V must contain the $v_0(i), i = 1(1)18$, which corresponds to t_0. V will contain the values of v corresponding to the t contained in T only for the end-of-step exits.
+70–104	*VD*	Storage for the 18 DP floating-point values of the first derivatives, $\dot{v}_0(i), i = 1(1)18$ corresponding to t_0. These cells are used only during the initialization procedure and if $N = 0$, are not used at all.
+106–140	*VDD*	Storage for the 18 DP floating-point values of the second derivative, $\ddot{v}(i), i = 1(1)18$, which are computed by the user's derivative routine. These cells are unused if $N = 0$.
+142–158	MATRIX	Storage for the nine DP floating-point elements of the 3×3 A matrix described in Section h-3. These elements are to be computed by the user's derivative subroutine during the starting procedure for the variational equations. The derivative subroutine may use this space as necessary at all other times.
+160–194	*XDL*	The $M + 3$ DP values of the differences $\nabla^{-2}\ddot{x}$, $\nabla^{-1}\ddot{x}$, $\ddot{x}$, $\nabla\ddot{x}$, $\cdots$, $\nabla^{M}\ddot{x}$.
+196–230	*YDL*	Same as *XDL* except that it contains the $\ddot{y}$ difference line.
+232–266	*ZDL*	Same as *XDL* except that it contains the $\ddot{z}$ difference line.
+268–914	*VDL*	This block of the communication region contains the $18(M + 3)$ DP values of the 18 difference lines $\nabla^{-2}\ddot{v}_i$, $\nabla^{-1}\ddot{v}_i$, $\ddot{v}_i$, $\nabla\ddot{v}_i$, $\cdots$, $\nabla^{M}\ddot{v}_i$, $i = 1(1)18$. The array is not packed, i.e., the $\nabla^{-2}\ddot{v}_{i+1}$ term is always 18 DP locations above the term $\nabla^{-2}\ddot{v}_i$.
+916–3100	BUFF	Working space required by FORTSZ. It is noted that the block of storage actually used by this program will be smaller than indicated if $OPT \neq 2$. In this case the user may provide for a smaller sized buffer region. If $N = 0$, the upper limit 3100 may be replaced by 2408. If $N = 1$, the upper limit may be replaced by $2408 + 18M$.

e. Space required.

The IBM 7090 version of FORTSZ requires 2768 (5320_8) storage locations. The user must allow for the communications region described under USAGE, Subroutine SCALR. The 7094 version is smaller (4752_8) as one instruction will replace each two-instruction DP macro in the 7090 version.

f. Coding.

This program has been coded for use with the IBM 7094 as well as the 7090. The following changes must be made in the source program to implement the 7094 capability: Remove all macro definitions from FORTSZ, SMULT, XPAND, INTRP, and SCALR. Check that the DP storage in these routines (and the communication

region) is compatible with the final specifications for 7094 DP storage. It is expected that this will involve no more than adding a spacer to insure that the DP storage starts in an even cell. No other changes should be needed. The subroutine DPARTH will not be required by the 7094 version of FORTSZ.

g. Subroutines.

FORTSZ uses the auxiliary subroutines DPARTH, SCALR, XPAND, SMULT, and INTRP. These programs have been documented separately. In addition, the user must provide a subroutine to evaluate the derivatives, one to compute the step size, and an appropriate end-of-step routine. The presence of T stop subroutines is optional. The requirements for these user-coded programs is detailed under USAGE.

h. Basic formulas.

1. Gauss-Jackson integration formulas*

   a. The Gauss-Jackson method is usually described in terms of a single central difference formula (Ref. 8). The primary idea which sets this procedure apart from other similar integration methods is the definition and use in computation of two inverse difference functions. For the purpose of this discussion, any integration formula which makes use of this inverse difference technique will be referred to as a member of the Gauss-Jackson family, thus enlarging the scope of the more normal definition.

   These inverse functions are defined by the relations

$$\nabla^{-1}u_n - \nabla^{-1}u_{n-1} = u_n \qquad \text{(A-1)}$$

$$\nabla^{-2}u_n - \nabla^{-2}u_{n-1} = \nabla^{-1}u_n \qquad \text{(A-2)}$$

   The operators ∇^{-1} and ∇^{-2} are called the first and second sums.

   b. Two basic Gauss-Jackson formulas are employed in this program. These are:

$$\dot{u}(t_{n-k}) = \frac{h(1-\nabla)^k}{-\ln(1-\nabla)}\ddot{u}(t_n) = h\sum_{i=-1}^{\infty} d_{i,k}\nabla^i\ddot{u}(t_n) \qquad \text{(A-3)}$$

$$u(t_{n-k}) = \frac{h^2(1-\nabla)^k}{\ln^2(1-\nabla)}\cdot\ddot{u}(t_n) = h^2\sum_{i=-2}^{\infty} f_{i,k}\nabla^i\ddot{u}(t_n) \qquad \text{(A-4)}$$

   where $\nabla^0\ddot{u} = \ddot{u}$, h is the step size, and n and k are integers. Equations (A-3) and (A-4) are easily derived by combining the methods of Ref. 7 and the properties of the first and second sums.

   It should be noted that $k = -1$ produces an open integration formula, $k = 0$ gives a closed integration formula, and values of k such that $1 \leq k$ provide formulas for computing past values of the variable u in terms of a difference line at t_n.

   The coefficients $d_{i,k}$ and $f_{i,k}$ exist in this program as prestored constants for all i such that $-2 \leq i \leq 15$ and all k such that $-1 \leq k \leq 15$.

2. Taylor series solution of the two-body problem

   It may be shown (see Ref. 3, Chap. 1, Section 30) that

$$R = R_0\sum_{j=0}^{\infty} a_j(t-t_0)^j + \dot{R}_0\sum_{j=0}^{\infty} b_j(t-t_0)^j \qquad \text{(A-5)}$$

   where $R = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$ is a solution of $\ddot{R} = \frac{-\mu R}{r^3}$,

   $r = |R|$, and μ is the gravitational constant. Capital letters are employed to represent vectors and matrices in this section.

   By truncating this series with $j = 6$ an approximation to R is obtained. The coefficients a_j and b_j are computed as follows:

   a. $p = \frac{(R_0, \dot{R}_0)}{r_0^2} = \frac{\dot{r}_0}{r_0}$

   where $(R_0, \dot{R}_0)$ is the inner product of R_0 and $\dot{R}_0$.

   b. $p_1 = p^2 = \frac{\dot{r}_0^2}{r_0^2}$

   c. $p_2 = \frac{(\dot{R}_0, \dot{R}_0)}{r_0^2} - \frac{2\mu}{r_0^3} = \frac{V_0^2}{r_0^2} - \frac{2\mu}{r_0^3}$

   d. $a_0 = b_1 = 1, \quad a_1 = b_0 = b_2 = 0$

   e. $a_2 = -\frac{\mu}{2r_0^3} \quad a_3 = -a_2 p \quad b_3 = \frac{a_2}{3} \quad b_4 = \frac{a_3}{2}$

*The notation employed in this Section is defined in detail in Ref. 7. A familiarity with this reference will be assumed throughout. Section 5.5 contains a development which is very much like that needed to obtain the above formulas.

f. $c_0 = -2a_2$

$c_1 = -6a_3$

$c_2 = 15pa_3 - 3a_2(2a_2 - p_2)$

$c_3 = -a_3(35[\ ] + 32a_2 - 15p_2)$

$c_4 = \frac{a_3}{2}(p(157.5p_1 - 105p_2) - 233a_3)$

$- a_2(a_2(16a_2 - 15.5p_2) + 3.75p_2^2)$

g. $a_4 = -\frac{1}{12}(c_0a_2 + c_2)$

$a_5 = -\frac{1}{20}(c_0a_3 + c_1a_2 + c_3)$

$a_6 = -\frac{1}{30}(c_0a_4 + c_1a_3 + c_2a_2 + c_4)$

$b_5 = -\frac{1}{20}(c_0b_3 + c_2)$

$b_6 = -\frac{1}{30}(c_0b_4 + c_1b_3 + c_3)$

3. Variational equations starting relations

a. The first-order variational coefficients $\partial R/\partial w_j$, where $\{w_j\} = \{x_0, y_0, z_0, \dot{x}_0, \dot{y}_0, \dot{z}_0\}$, may be written as the 3×6 matrix

$$W = \left(\frac{\partial R}{\partial w_j}\right) = \left(\frac{\partial R}{\partial x_0}, \frac{\partial R}{\partial y_0}, \frac{\partial R}{\partial z_0}, \frac{\partial R}{\partial \dot{x}_0}, \frac{\partial R}{\partial \dot{y}_0}, \frac{\partial R}{\partial \dot{z}_0}\right)$$

It is demonstrated in Ref. 9 that there exists a symmetric 3×3 matrix A such that

$$\ddot{W} = AW \qquad \text{(A-6)}$$

where A is not a function of the elements of W. It is noted that A is the matrix which the user's derivative subroutine must compute and store in the array MATRIX during the variational equations starting procedure.

b. Consider Equation (A-5). It follows that

$$\frac{\partial R}{\partial w_k} = \frac{\partial R_0}{\partial w_k}\sum_{j=0}^{\infty} a_j(t - t_0)^j + \frac{\partial \dot{R}_0}{\partial w_k}\sum_{j=0}^{\infty} b_0(t - t_0)$$

$$+ R_0\sum_{j=0}^{\infty}\frac{\partial a_j}{\partial w_k}(t - t_0)^j$$

$$+ \dot{R}_0\sum_{j=0}^{\infty}\frac{\partial b_j}{\partial w_k}(t - t_0)^j$$

or

$$\frac{\partial R}{\partial w_k} = \frac{\partial R_0}{\partial w_k}\sum_{j=0}^{\infty} a_j(t - t_0)^j$$

$$+ \frac{\partial \dot{R}_0}{\partial w_k}\sum_{j=0}^{\infty} b_j(t - t_0)^j + D \qquad \text{(A-7)}$$

A first approximation to the matrix may be obtained by computing only the first two terms of Eq. (A-7). No attempt is made to justify neglecting the term D. D is deleted only to simplify the computation. It is intended that any first approximation will be improved by a subsequent iterative scheme. This computation thus need only be close enough to the actual solution to make the iteration converge.

4. Starting procedure convergence test

An iterative procedure is employed by this program to generate an initial set of difference lines $\nabla^i\ddot{u}_j$ $i = -2(1)M$, $j = 1(1)3$ or 21, where the 3 will be used if the variational equations are not to be solved. The dummy variable u_j is thus defined as $u_1 = x$, $u_2 = y$, $u_3 = z$ and $u_i = v_{i-3}$ $i = 4(1)21$ to simplify the notation.

After each iteration, compute for each difference line generated, the factor

$$E_j = \max_{-2 \le i \le M}\left|\frac{(\nabla^i\ddot{u}_{new} - \nabla^i\ddot{u}_{old})}{\max_{-2 \le i \le M}(\nabla^i\ddot{u}_{new})}\right|$$

over all applicable j. Then let

$$E = \max_j (E_j).$$

This routine decides that a sufficiently accurate set of differences has been generated in one of two ways:

a. ES positive. The iteration will be terminated as soon as $E < ES$, where ES is the input parameter defined earlier.

b. ES negative. The iteration will be terminated if $E < |ES|$ and if $E_{old} - E_{new} = 0$. The second condition permits the user to obtain, in most cases, the best difference lines possible without needing to precisely specify ES.

5. Change of step

a. Doubling

This routine doubles the integration step size by saving enough of the previously computed second derivatives to allow a straightforward computation of the double interval differences $\nabla^i_{2h}\ddot{u}_j$, $i = 1(1)M$, and all j, by differencing. This means that the last $2M + 1$ second derivatives of each variable must be available before a step size increase can be made. As $M + 1$ second derivatives are implicitly contained in the difference lines, this implies that M steps must be taken after the initialization or after each step change before the step doubling procedure may be executed. Any attempt to double the step will be ignored until the requisite derivatives have been computed.

Once the double size differences $\nabla^i_{2h}\ddot{u}_j(t_n)$, $i = 0(1)M$, all j, have been obtained, the first sums are computed using Eq. (A-3) and the fact that the first derivative of a variable at t_n must be the same when expressed in terms of either the old differences $\nabla^i_h\ddot{u}_j(t_n)$ or the new differences $\nabla^i_{2h}\ddot{u}_j(t_n)$. The actual relation is

$$\nabla^{-1}_{2h}\ddot{u}_j(t_n) = \frac{1}{2}\nabla^{-1}_h\ddot{u}_j(t_n) + \sum_{k=0}^{M} d_{k,0}\left(\frac{1}{2}\nabla^k_r\ddot{u}_j(t_n) - \nabla^k\ddot{u}_j t_n\right)$$

Finally, the second sums are computed using Eq. (A-4):

$$\nabla^{-2}_{2h}\ddot{u}_j(t_n) = \frac{u_j(t_n)}{4h^2} - \sum_{k=-1}^{M} f_{k,0}\nabla^k_{2h}\ddot{u}_j(t_n)$$

b. Halving

Halving is accomplished by computing the half step differences,

$$\nabla^i_{h/2}\ddot{u}_j(t_n),$$

$i = 1(1)M$, all j, from the following subtabulation formula (see Ref. 7, Section 5.7):

$$\nabla^i_{h/2}\ddot{u}_j = \left(\frac{1}{2}\nabla_h + \frac{1}{2^2\cdot 2!}\nabla^2_h + \frac{1\cdot 3}{2^3\cdot 3!}\nabla^3_h + \frac{1\cdot 3\cdot 5}{2^4\cdot 4!}\nabla^4_h + \cdots\right)^i\cdot\ddot{u}_j$$

Once these new differences have been computed, a scheme identical to that used in doubling is employed to obtain the new first and second sums. The formulas are

$$\nabla^{-1}_{h/2}\ddot{u}_j(t_n) = 2\nabla^{-1}_h\ddot{u}_j(t_n) + \sum_{k=0}^{M} d_{k,0}\left(2\nabla^k_n\ddot{u}_j(t_n) - \nabla^k_{h/2}\ddot{u}_j t_n\right)$$

$$\nabla^{-2}_{h/2}\ddot{u}_j(t_n) = \frac{4u_j(t_n)}{h^2} - \sum_{k=-1}^{M} f_{k,0}\nabla^k_{h/2}\ddot{u}_j(t_n)$$

i. Method.

1. First approximation

Equation (A-5) is used to obtain a first approximation to the positional coordinates and variational coefficients on a net of $M + 1$ points. The variational coefficients are generated under the approximation noted in Section h-3 by replacing R_0 and $\dot{R}_0$ in Eq. (A-5) by $\partial R_0/\partial w_i$ and $\partial\dot{R}_0/\partial w_i$.

2. Coordinate improvement

The first approximations to the $M + 1$ values of x, y, and z allow the computation of the second derivatives of these quantities at these $M + 1$ points. These second derivatives are used to compute the required differences $\nabla^i\ddot{u}_j$ $i = 1(1)M$, $j = 1(1)3$. Let the initial values be denoted by $u_j(t_s)$ and $\dot{u}_j(t_s)$.

The first and second sums of $u_j(t_n)$ are then given by Eqs. (A-3) and (A-4) as

$$\nabla^{-1}\ddot{u}_j(t_n) = \frac{\dot{u}_j(t_s)}{h} - \sum_{i=0}^{M} d_{i,n-s}\nabla^i\ddot{u}_j(t_n), \quad j = 1(1)3$$

and

$$\nabla^{-2}\ddot{u}_j(t_n) = \frac{u_j(t_s)}{h^2} - \sum_{i=-1}^{M} f_{i,n-s}\nabla^i\ddot{u}_j(t_n), \quad j = 1(1)3$$

Thus a complete set of differences is obtained for each coordinate. Equation (A-4) is next employed with $k = 0(1)M$ to generate a next approximation to u_i, $i = 1(1)3$ at each of the $M + 1$ net points. The convergence test described above determines whether the iteration is to be terminated. If the iteration is not to be terminated, a new iteration is commenced. If it is to be terminated, the program will begin to generate the difference lines for the variational equations or, if they are not required, begin the integration procedure.

3. Variational coefficient improvement.

The user's derivative subroutine is called to provide the matrices A, discussed in Section h-3, for each of the $M + 1$ points of the net. As the matrices depend only on the coordinates and the time, and as these quantities are, at this point in the computation, well known on the net, this procedure has been adopted to prevent the generation of these matrices more than once. The relation (Eq. A-6) and the first approximations to the variational coefficients generated are used to obtain the values of the second derivatives of the 18 elements of W. The iterative improvement procedure for the variational coefficients difference lines is, from this point, identical with that used to obtain the difference lines for each of the coordinates. When the convergence test indicates that the difference lines are sufficiently consistent, the integration is commenced.

4. Integration procedure.

The integration is accomplished by one of three methods:

a. Gauss-Jackson open procedure.

Equation (A-4) is used with $k = -1$ to advance the calculation. The new values of the dependent variables are employed to update the difference lines.

b. Gauss-Jackson pseudo predictor corrector procedure.

Equation (A-4) is applied as above. No further change is made to the difference lines, but an improved value of each of the variables is calculated by Eq. (A-4) with $k = 0$. This procedure requires only one entry to the user's derivative subroutine per step.

c. Gauss-Jackson predictor corrector procedure.

Equation (A-4) is used with $k = 1$ and $k = 0$ as a standard predictor-corrector scheme. The corrector is applied only once. This procedure requires two entries to the user's derivative subroutine per step.

3. XPAND

John Van de Wouw, Computer Sciences Corporation, April 26, 1962.

a. Purpose.

This subroutine generates the first $(i + 1)$ coefficients in the expansion of $(1 - \nabla)^\alpha$ using DP arithmetic.

b. Method.

The expansion of $(1 - \nabla)^\alpha$ is given by

$$(1 - \nabla)^\alpha = 1 - \alpha\nabla + \frac{\alpha(\alpha - 1)}{2!}\nabla^2 - \frac{\alpha(\alpha - 1)(\alpha - 2)}{3!}\nabla^3 + \cdots$$

Let this be written as

$$(1 - \nabla)^\alpha = \beta_0 + \beta_1\nabla + \beta_2\nabla^2 + \beta_3\nabla^3 + \cdots$$

Then

$$\beta_0 = 1$$

$$\beta_i = -\frac{(\alpha - i + 1)}{i}\beta_{i-1} \qquad i > 0$$

c. Usage.

Calling sequence:

γ	CALL	XPAND	or	TSX $XPAND,4
$\gamma + 1$	PZE	ALPHA, , N		
$\gamma + 2$	PZE	BETA		
$\gamma + 3$	Return			

where

ALPHA = the location of α (floating-point, DP).

N = number of coefficients in series BETA.

BETA = the first of $2N$ locations where $\beta_0, \beta_1, \cdots, \beta_i$ will be stored as DP numbers.

d. Storage.

104_8 locations.

4. SMULT

John Van de Wouw, Computer Sciences Corporation, April 26, 1962.

a. Purpose.

This subroutine generates the coefficients of the first n terms in the product of two series of n terms each using DP arithmetic.

b. Method.

Let series

$A = (a_1, c_2, \cdots, a_n)$, and series

$B = (b_1, b_2, \cdots, b_n)$. Then $A * B = C$, where

$C = (c_1, c_2, \cdots, c_n)$

$c_1 = a_1 b_1$

$c_2 = a_1 b_2 + a_2 b_1$

$c_n = \sum a_i b_j$ over all i, j such that $i + j - 1 = n$

c. Usage.

Calling sequence:

α	CALL	SMULT	or	TSX	$SMULT 4
$\alpha + 1$	PZE	A, , B			
$\alpha + 2$	PZE	C, , N			
$\alpha + 3$	Return				

where

A = the first location of a block of $2n$ locations containing $a_1, a_2, \cdots, a_n$ in DP.

B = the first location of a block of $2n$ locations containing $b_1, b_2, \cdots, b_n$ in DP.

C = the first location of a block of $2n$ locations where the series $c_1, c_2, \cdots, c_n$ will be stored in DP.

$N = n$, number of coefficients in A, B and C.

d. Storage.

52_8 locations.

5. SCALR

DP Innerproduct Routine. J. H. Beeman, Computer Sciences Corporation, August 8, 1962.

Machine: IBM 7090/94.

a. Purpose.

This subroutine computes the innerproduct of two vectors in DP.

b. Method.

Let

$$A = (a_1, a_2, \cdots, a_n) \text{ and}$$
$$B = (b_1, b_2, \cdots, b_n)$$

be two vectors. Then the innerproduct of A and B is the number

$$(A, B) = \sum_{i=1}^{n} a_i b_i \qquad \text{(A-8)}$$

This program forms (A, B) by summing the DP products $a_i b_i$ in the order $i = N(-1)1$.

c. Restrictions.

This is a FAP-coded subroutine which is FORTRAN IV compatible. Arrays must be forward stored. Fixed-point variables and constants are stored in the address of their storage location. The low-order part of a DP floating-point quantity is stored directly above the high-order part in an array.

d. Usage.

Calling sequence.

CALL SCALR (A, B, N, ANS)

where

A = the first location of $2N$ cells which contain the DP floating-point vector A.

B = the first location of $2N$ cells which contain the DP floating-point vector B.

N = the fixed point integer giving the number of elements in vectors A and B.

ANS = the DP floating-point storage location assigned to the quantity (A, B).

e. Storage.

IBM 7090 version: 40 (50_8) locations.

IBM 7094 version: 32 (40_8) locations.

f. Coding.

The IBM 7094 compatibility of this routine may be implemented by removing the six DP macro instructions from the 7090 version.

g. Subroutines required.

IBM 7090 version: DPARTH, a 7094 DP arithmetic subroutine.

IBM 7094 version: None required.

6. INTRP

DP Derivative Interpolation Routine. R. J. Krekemeyer, Computer Sciences Corporation, August 10, 1962.

Machine: IBM 7090/94.

a. Purpose.

Let $\nabla^{-2}\ddot{u}_n$, $\nabla^{-1}\ddot{u}_n$, $\cdots$, $\nabla^{M}\ddot{u}_n$ be a set of DP Gauss-Jackson Mth order backward differences in terms of the second derivatives of a variable u. If t_n is the value of the independent variable corresponding to this difference line, the routine will employ these differences to interpolate for the value of $u(t)$, $\dot{u}(t)$, $\ddot{u}(t)$, or $\dddot{u}(t)$ for any t such that $t_n \geqq t \geqq t_{n-M}$.

b. Method.

The differences, $\nabla^i\ddot{u}_n$, $i = -2(1)M$ are provided by the user. The difference interval is understood to be h, i.e.,

$$\nabla^i\ddot{u}_n = \nabla^i\ddot{u}(t_n) = \nabla^i\ddot{u}(t_0 + nh)$$

It may be verified (see Refs. 7 and 8) that

$$f_{n-\alpha} = f(t_n - \alpha h) = (1 - \nabla)^\alpha f_n = \sum_{k=0}^{\infty} p_k(\alpha)\nabla^k f_n \tag{A-9}$$

where α is a real number.

$$u_n = \frac{h^2}{\ln(1-\nabla)^2}\ddot{u}_n = \sum_{k=-2}^{\infty} a_k\nabla^k\ddot{u}_n \tag{A-10}$$

$$\dot{u}_n = \frac{-h}{\ln(1-\nabla)}\ddot{u}_n = \sum_{k=-1}^{\infty} b_k\nabla^k\ddot{u}_n \tag{A-11}$$

$$\ddot{u}_n = \ddot{u}_n \tag{A-12}$$

$$\dddot{u}_n = -\frac{1}{h}\ln(1-\nabla)\ddot{u}_n = \sum_{k=1}^{\infty} c_k\nabla^k\ddot{u}_n \tag{A-13}$$

Multiplying Eq. (A-9) by Eqs. (A-10), (A-11), (A-12) and (A-13) produces interpolation formulas for $u_{n-\alpha}$, $\dot{u}_{n-\alpha}$, $\ddot{u}_{n-\alpha}$ and $\dddot{u}_{n-\alpha}$ in terms of the available differences of the second derivatives of u. The coefficients a_k, b_k, and c_k, $k = -2(1)15$ exist within INTRP as prestored constants. Subroutine XPAND is employed to generate the coefficients of Eq. (A-9). Subroutine SMULT multiplies the coefficients of Eq. (A-9) by the coefficients of the user-selected series Eqs. (A-10) through (A-13). Subroutine SCALR multiplies each computed coefficient by the corresponding difference and sums the resulting series to give the interpolated value of the desired variable. All calculations are made in DP.

c. Restrictions.

1. This is a FAP-coded subroutine which is FORTRAN IV compatible. This implies that arrays are forward stored, that the low-order part of a DP word is stored directly above the high-order part, and that fixed-point quantities are stored as full-word integers.
2. Extrapolation is not allowed. If t, n, and M are as defined under PURPOSE, t must be such that $t_n \geqq t \geqq t_{n-M}$.
3. This program has been coded for use with both the IBM 7090 and 7094.

d. Usage.

Calling sequence:

CALL INTRP $(T, TS, D, H, N, M, ANS,$ ERROR)

where

$T = t_n$, the double precision floating point (DPFP) value of the independent variable corresponding to the difference line D.

$TS = t$, the DPFP value of the independent variable for which the dependent variable designated by N is to be computed.

D = DPFP array of at least $2M + 6$ locations containing $\nabla^k\ddot{u}_n = \nabla^k\ddot{u}(T)$, $k = -2(1)M$.

$H = h$, the DPFP value of the interval on which the differences D have been computed.

N = Fixed-point integer designating the variable to be computed by INTRP.

$N = 0$ compute $u(TS)$
$N = 1$ compute $\dot{u}(TS)$
$N = 2$ compute $\ddot{u}(TS)$
$N = 3$ compute $\dddot{u}(TS)$

M = Fixed-point integer giving the order of the differences contained in D.

ANS = DPFP value of the variable returned by INTRP.

ERROR = Name of the user's error subroutine. This subroutine will be called if TS does not fall in the range $T \geqq TS \geqq (T - M \cdot H)$. Note that an F card must be included in the calling program to define ERROR as a subroutine.

e. Storage.

IBM 7090 version: 340 (524_8) locations.

f. Coding.

This routine has been designed for use with the IBM 7094 as well as the 7090. The 7090 version may be altered to a 7094 program by:

1. Removing the macro definitions from the program.

2. Insuring that the DP storage (TEMP and below, including the prestored coefficients) is compatible with the final specification for 7094 DP storage. This should involve no more than relocating the program address TEMP to an even cell.

g. Subroutines required.

IBM 7090 version: ERROR, SCALR, SMULT, XPAND, DPARTH

IBM 7094 version: ERROR, SCALR, SMULT, XPAND

ERROR must be provided by the user (see Usage). The remaining subroutines are documented separately.

7. TSTOP

DP time stop routine for the computation of residuals and ephemeris printing and tape writing. C J. Devine, JPL.

Machine: IBM 7090/94. Language: Fortran II.

a. Purpose.

This subroutine is intended to obtain the integrated coordinates of an ephemeris from common storage, read a source tape for source coordinates and compute residuals of observed minus computed coordinates. It will also call a subroutine to compute residuals in latitude, longitude, and ρ from the coordinate residuals After the above computation, the subroutine is used to write a converged ephemeris tape and/or a residual tape. TSTOP will also write a preconverged residual tape of $n-1$ iterations, corresponding to $n-1$ files of information.

b. Method.

Let x_0^i be the observed ephemeris coordinates $(i = 1, 2, 3)$.

Let x_c^i be the computed ephemeris coordinates $(i = 1, 2, 3)$.

Then the residuals in rectangular coordinates are formed by

$$\Delta x^i = x_0^i - x_c^i \qquad (i = 1, 2, 3) \qquad \text{(A-14)}$$

The residuals in longitude, latitude, and ρ are formed by calling the subroutine STINKS, which also rotates position-velocity coordinates to the ecliptic system. TSTOP will also print the ephemeris and residuals as outlined in Section D-2.

c. Usage.

Calling sequence:

CALL TSTOP (NTAPE, LTAPE, KTAPE, DELTA, TIME, DELT, COSOB, SINOB CMAT, XLB, XJDO, XYZ, VXYZ, KAM, LAM, KAN, NWRITE, NPRINT)

where

NTAPE = the user's logical tape unit number for the source ephemeris tape. The subroutine expects the following tape format: READ TAPE NTAPE, JD, x^i $(i = 1, 2, 3)$, $\dot{x}^i$ $(i = 1, 2, 3)$ where all quantities are DP, with the most significant part first.

LTAPE = the user's logical tape unit number for the ephemeris write tape. The format is the same as above.

KTAPE = the user's logical tape unit number for the residual write tape. The format of the tape is JD (DP), ΔX, ΔY, and ΔZ (SP), $\Delta\rho$, $\cos\beta\Delta\lambda$, and $\Delta\beta$ (SP).

DELT = the 3×1 matrix of ecliptic longitude, latitude, and ρ residuals, i.e., $\cos\beta\Delta\lambda$, $\Delta\beta$, $\Delta\rho$ supplied by TSTOP. This quantity is computed by the rotation matrix STINKS.

TIME = the total elapsed time, $t_n - t_0$ (DP), computed by TSTOP.

DELTA = the 3×1 DP matrix of equatorial residuals of rectangular coordinates computed by TSTOP.

COSOB = the DP cosine of the obliquity supplied by the user.

SINOB = the DP sine of the obliquity supplied by the user.

CMAT = 3×3 DP matrix supplied by the rotation matrix STINKS for multiplication by SET III matrix.

XLB = the 3×1 matrix of ecliptic ρ, longitude, and latitude from computed XYZ.

XJDO = DP starting integration date supplied by the user.

XYZ = DP 3×1 matrix of ecliptic position coordinates computed by TSTOP.

VXYZ = DP 3×1 matrix of ecliptic velocity coordinates computed by TSTOP.

KAM = integer flag supplied by user for separate computation check of $\Delta\rho$, $\Delta\lambda$, $\Delta\beta$.
KAM = 1 Yes
KAM = 2 No

LAM = integer flag supplied by user for printing of ephemeris during iteration.
LAM = 1 Yes
LAM = 2 No

KAN = integer flag supplied by user for printing of ephemeris on final converged iteration.
KAN = 1 Yes
KAN = 2 No

NWRITE = internal integer flag set by driver program for tape writing. NWRITE = 2 during iterations, NWRITE = 1 for convergence, tape writing may proceed.

NPRINT = integer flag supplied by user for choice of tape writing.
NPRINT = 1 Write ephemeris and residual.
NPRINT = 2 Write ephemeris only.
NPRINT = 3 Write residual only.
NPRINT = 4 No tapes to be written.

The quantities in the calling sequence must be dimensioned in the driver program as follows:

```
D DIMENSION DELTA(3), TIME(1), DELT(3),
COSOB(1), SINOB(1), CMAT(3,3), XLB(3),
XJDO(1), XYZ(3), VXYZ(3)
```

The position and velocity and time must be stored by the user's program at each time stop in common in the following order:

```
DIMENSION DUMMY(4972), VZL(1),
VZM(1) · · · , VXM(1), ZL(1), ZM(1), · · · ,
XL(1), XM(1), JDL(1), JDM(1)
```

i.e., starting with velocity in descending storage order, with the least significant part first.

d. Remarks.

A flow chart of the TSTOP logic may be found in Section F of this Appendix.

e. Subroutines required.

STINKS Described below.

SPHER Called by subroutine STINKS (described below).

8. STINKS

DP system increments rotation subroutine. C. J. Devine, JPL.

Machine: IBM 7090/94; Language: Fortran II.

a. Purpose.

This subroutine obtains DP rotation of position-velocity coordinates, residuals, and computes ρ, longitude and latitude from the rotated coordinates. STINKS will also compute the 3×1 residual matrix $(\cos\beta\Delta\lambda, \Delta\beta, \Delta\rho)$ and the special C-matrix described in Section III of the descriptive text of this Report.

b. Method.

Given position-velocity coordinates x^i, $\dot{x}^i$ and residuals Δx^i $(i = 1, 2, 3)$, they may be rotated by the following matrix multiplication:

$$\begin{pmatrix} \bar{x}^1 \\ \bar{x}^2 \\ \bar{x}^3 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\varepsilon & \pm\sin\varepsilon \\ 0 & \mp\sin\varepsilon & \cos\varepsilon \end{pmatrix} \begin{pmatrix} x^1 \\ x^2 \\ x^3 \end{pmatrix} \quad \text{(A-15)}$$

where $\bar{x}^i$ are the transformed quantities.

Then the matrices $(\cos\beta\Delta\lambda, \Delta\beta, \Delta\rho)$ and the C-matrix may be computed by the following equation:

$$\begin{pmatrix} \cos\beta\Delta\lambda \\ \Delta\beta \\ \Delta\rho/\rho \end{pmatrix} = \frac{1}{\rho} \begin{pmatrix} -\sin\lambda & \cos\lambda & 0 \\ -\sin\beta\cos\lambda & -\sin\beta\sin\lambda & \cos\beta \\ x^1/\rho & x^2/\rho & x^3/\rho \end{pmatrix} \begin{pmatrix} \Delta x^1 \\ \Delta x^2 \\ \Delta x^3 \end{pmatrix} \quad \text{(A-16)}$$

where the Δx^i are the rotated residuals, and λ, β, and ρ have been found from the subroutine SPHER by the usual spherical coordinate methods.

c. Usage.

Calling sequence:

```
CALL STINKS (XYZ, X1DOT, DELTA,
XLB, CMAT, COSOB, SINOB, NROT)
```

where

XYZ = the DP position vector supplied by the user.

X1DOT = the DP velocity vector supplied by the user.

DELTA = the DP residual vector supplied by the user.

XLB = the DP vector of ρ, β, and λ, computed by SPHER.

CMAT = the DP 3 × 3 C-matrix described in Eq. (A-16).

COSOB = the DP cosine of the obliquity.

SINOB = the DP sine of the obliquity.

NROT = 2, the integer flag for rotation only; or NROT = 1, rotation and matrix computation.

The user must provide DP storage capability in the driver as follows:

```
D DIMENSION XYZ(3), X1DOT(3), DELTA(3),
            XLB(3), CMAT(3,3), COSOB(1),
            SINOB(1)
```

If it is desired only to rotate position and/or velocity, then all that is required is to set NROT = 2, and supply the desired coordinates, including appropriate dummy dimensions for the rest of the calling sequence.

d. Remarks.

The rotated values of the position and velocity coordinates and the new residual vector $\cos\beta\Delta\lambda, \Delta\beta, \Delta\rho$ are returned to the user in the same storage locations, i.e., in XYZ, X1DOT, and DELTA, respectively.

e. Subroutines required.

SPHER. Described later.

9. SET32

The DP SET III matrix of partial derivatives of the osculating elements. C. J. Devine, JPL.

Machine: IBM 7090/94; Language: Fortran II.

a. Purpose.

To compute in DP a modified form of the SET III partial derivatives of the osculating elements of Brouwer and Clemence (Ref. 3, p. 241), i.e., to compute a 3 × 6 matrix of partial derivatives of λ, β, and ρ with respect to the SET III of PLOD I.

b. Method.

Given the ecliptic osculating elements a_0, n_0, e_0, i_0, Ω_0, ω_0, and M_0 along with ecliptic position-velocity coordinates and an PQR-direction cosine matrix, it is desired to compute the following matrix:

$$\bar{A}_{3\times 6} = \mathrm{CMAT}_{3\times 3} * (\mathrm{SET\ III})_{3\times 6} = \frac{\partial(L,\beta,\rho)}{\partial(\mathrm{SET\ III})} \tag{A-17}$$

or as in Eq. (23) of the text,

$$\bar{A} = CA \tag{A-18}$$

where C is the C-matrix described in STINKS and A is the SET III matrix of Ref. 3 and Eq. (15) of the text.

c. Usage.

Calling sequence:

```
CALL SET32 (PQR, XYZ, X1DOT, A,
    E, XN, SET, TIME, CMAT)
```

where

PQR = the DP 3 × 3 direction cosine matrix supplied by the user. The P vector is the first row, the Q vector is the second row and the R vector is the last row.

XYZ = the DP ecliptic position vector supplied by the user.

X1DOT = the DP ecliptic velocity vector supplied by the user.

A = the DP semimajor axis of the ellipse.

E = the DP eccentricity of the ellipse.

XN = the DP mean motion of the osculating elements.

SET = the DP matrix A computed by SET32.

TIME = the DP elapsed time $t_n - t_0$, supplied by the user.

CMAT = the 3 × 3 DP C-matrix described above.

The arguments in the calling sequence must be dimensioned as follows:

```
D DIMENSION PQR(3,3), XYZ(3), X1DOT(3),
            A(1), E(1), XN(1), SET(6,6),
            TIME(1), CMAT(3,3).
```

d. Remarks.

SET32 is a modification of the original SET III matrix of PLOD I, called REL 3. Essentially, the difference for

PLOD II is that all quantities are now in the ecliptic system and there is a last multiplication by the C-matrix. Additionally, RED 3 had an acceleration capability that SET32 does not have, making it a possible 6×6 partial derivative matrix.

e. Subroutines required.

None.

10. SETUP2

DP accumulation of the normal equations. C. J. Devine, JPL.

Machine: IBM 7090/94; Language: Fortran II.

a. Purpose.

This subroutine accumulates the equations of condition obtained from the SET32 matrix, and tests for solution by STPRG2.

b. Method.

Let the system of linear equations obtained after $n + 1$ steps be denoted by $\mathbf{NX} = \mathbf{F}$, where $\mathbf{X}$ is the solution vector and $\mathbf{N}$ is computed by SETUP2 as follows:

$$\mathbf{N} = \sum_{j=0}^{N} \Delta \mathbf{N}_j \qquad \text{(A-19)}$$

where

$$\Delta \mathbf{N}_j = \bar{\mathbf{A}}_j^* \mathbf{W} \bar{\mathbf{A}}_j \qquad \text{(A-20)}$$

at each step, $\bar{\mathbf{A}}_j^*$ is the transpose of $\bar{\mathbf{A}}_j$, and $\mathbf{W}$ is a diagonal weight matrix,

$$\mathbf{W} = \begin{pmatrix} \alpha_1 & 0 & 0 \\ 0 & \alpha_2 & 0 \\ 0 & 0 & \alpha_3 \end{pmatrix} \qquad \text{(A-21)}$$

The matrix $\mathbf{F}$ is computed as

$$\mathbf{F} = \sum_{j=1}^{N} \Delta \mathbf{F}_j \qquad \text{(A-22)}$$

where

$$\Delta \mathbf{F}_j = \bar{\mathbf{A}}_j^* \mathbf{W} \bar{\mathbf{B}}_j$$

at each step, and where $\bar{\mathbf{B}}_j$ is the residual vector. A test is made at this point to determine whether

$$S = \sum_{j=0}^{k} [\alpha_1 (\cos \beta_j \Delta\lambda_j)^2 + \alpha_2 (\Delta\beta_j)^2 + \alpha_3 (\Delta\rho_j)^2] \geqq \delta$$
$$(20 \leq k \leq n) \qquad \text{(A-23)}$$

If it is, a solution is called for immediately.

c. Usage.

Calling sequence:

```
CALL SETUP2 (SET, DELTA, XNUM,
SIGSQ, AMAT, BMAT, MMAX,
NMAX, NGOSOL, STEST, WT)
```

where

SET = the DP matrix computed by SET32 (SET III matrix.

DELTA = the DP residual matrix ($\cos\beta\Delta\lambda, \Delta\beta, \Delta\rho$).

XNUM = the floating point DP number of integration steps.

SIGSQ = $\Sigma\alpha_1 (\cos\beta\Delta\lambda)^2 + \alpha_2 (\Delta\beta)^2 + \alpha_3 (\Delta\rho)^2$, the DP test value.

AMAT = the DP matrix, AMAT = N, in Eq. (A-19).

BMAT = the DP matrix, BMAT = F, in Eq. (A-20).

MMAX = the number of rows of the normal matrix, SET.

NMAX = the number of columns of the normal matrix, SET.

NGOSOL = the solution parameter set by SETUP2 on the STEST, if NGOSOL = 1; no solution, = 2 solve.

STEST = the DP number, δ, in Eq. (A-23).

WT = the DP weight vector WT = (1, 1, 0) for PLOD II type runs, (1, 1, 1) for PLOD I type runs.

The above quantities must be dimensioned as follows:

```
D DIMENSION  SET(6,6), DELTA(3), XNUM(1),
             SIGSQ(1), AMAT(6,6), BMAT(6),
             STEST(1), WT(3)
```

d. Subroutines required.

None required.

11. CORECT

The DP computation of corrections to the osculating elements from the solution vector of the normal equations. C. J. Devine, JPL.

Machine: IBM 7090/94; Language: Fortran II.

a. Purpose.

This subroutine is intended to compute corrections to the osculating elements given the solution vector to the normal equations. CORECT will then compute new osculating elements and a new PQR direction cosine matrix.

b. Method.

Given the solution vector $\mathbf{X} = (\Delta M_0 + \Delta r, \Delta p, \Delta q, e\Delta r, \Delta a/a, \Delta e)$, and osculating elements $a_0, n_0, e_0, i_0, \Omega_0, \omega_0, M_0$, with a direction cosine matrix

$$(\mathbf{PQR}) = \begin{pmatrix} \mathbf{P}_x & \mathbf{P}_y & \mathbf{P}_z \\ \mathbf{Q}_x & \mathbf{Q}_y & \mathbf{Q}_z \\ \mathbf{R}_x & \mathbf{R}_y & \mathbf{R}_z \end{pmatrix} \qquad \text{(A-24)}$$

computed from the osculating elements, CORECT will obtain corrections Δa, Δn, Δe, Δi, $\Delta\Omega$, $\Delta\omega$, ΔM_0 from the vector X and add them to the osculating elements. These new elements are then used to form a new direction cosine matrix.

c. Usage.

Calling sequence:

CALL CORECT (XSOLVE, MEAN, XMEAN, ELM, PQRN, XMU)

where

XSOLVE = the DP solution vector supplied by the user.

MEAN = the mean motion integer control flag.
MEAN = 1; mean motion computed (Δn is computed from $\mu = n^2a^3$).
MEAN = 2; mean motion held fixed (Δa is computed from $\mu = n^2a^3$).

XMEAN = the DP value of the mean motion supplied by the user for MEAN = 2.

ELM = the DP seven osculating elements (includes mean motion) supplied by user in the following order: a, n, e, i, Ω, ω, and M.

PQRN = the DP direction cosine matrix **PQR**.

XMU = the DP value of μ.

The 3×3 matrix **PQRN** is used to supply the old **PQR** matrix and to return the new one, similarly the vector ELM. The dimensions must be as follows:

D DIMENSION XSOLVE(6), XMEAN(1), ELM(7), PQRN(3,3), XMU(1)

d. Subroutines required.

DOUTPT DP output. At JPL, this is a library system subroutine.

12. TRANSX

The DP transformation from elliptic elements to rectangular coordinates using a solution of Kepler's equations. C. J. Devine, JPL. Machine: IBM 7090/94; Language: Fortran II.

a. Purpose.

This subroutine provides a DP transformation from elements a, n, e, i, Ω, ω, M_0, and direction cosines **PQR** to rectangular position-velocity coordinates using a solution of Kepler's equation.

b. Method.

Given the elliptic elements of the orbit, a, e, M_0, and $b = a\cos\Phi = a(1-e^2)^{1/2}$ and direction cosines **PQR**, then the position-velocity coordinates are obtained from the following equations:

$$\begin{aligned} X_0 &= a\mathbf{P}_x(\cos E - e) + b\mathbf{Q}_x \sin E \\ Y_0 &= a\mathbf{P}_y(\cos E - e) + b\mathbf{Q}_y \sin E \\ Z_0 &= a\mathbf{P}_z(\cos E - e) + b\mathbf{Q}_z \sin E \end{aligned} \qquad \text{(A-25)}$$

$$\begin{aligned} \dot{X}_0 &= [(b\mathbf{Q}_x \cos E - a\mathbf{P}_x \sin E)/ra^{1/2}]\,\mu^{1/2} \\ \dot{Y}_0 &= [(b\mathbf{Q}_y \cos E - a\mathbf{P}_y \sin E)/ra^{1/2}]\,\mu^{1/2} \\ \dot{Z}_0 &= [(b\mathbf{Q}_z \cos E - a\mathbf{P}_z \sin E)/ra^{1/2}]\,\mu^{1/2} \end{aligned} \qquad \text{(A-26)}$$

where E is determined from Kepler's equation.

$$M = M_0 + n(t - t_0) = E - e\sin E \qquad \text{(A-27)}$$

by a Newton-Raphson iteration.

c. Usage.

Calling sequence:

CALL TRANSX (PQR, DPXYZ, ELEM, XMU)

where

PQR = the DP direction cosine matrix supplied by the user (**P**, **Q**, and **R** are row vectors of the matrix).

DPXYZ = the DP position-velocity vector computed by TRANSX.

ELEM = the DP elliptic element vector supplied by the user, i.e., ELEM = $(a, n, e, i, \Omega, \omega, M_0)$.

XMU = the DP μ supplied by user for the scaling factor in the velocity solution $\mu = k^2(1 + m)$, where k is the gravitational constant and m is the mass of the body. Quantities are dimensioned as follows:

```
D DIMENSION PQR(3,3), DPXYZ(6),
ELEM(7), XMU(1)
```

13. DERIV

The DP acceleration routine. C. J. Devine, JPL.

Machine: IBM 7090/94; Language: Fortran II.

a. Purpose.

This subroutine provides a DP numerical evaluation of the fundamental equations of motion in Cowell's method of integration.

b. Method.

Given the DP position-velocity coordinates of the main body, x^i, $\dot{x}^i$ $(i = 1, 2, 3)$ and the DP mass (m) of the main body, with the position coordinates x^i, and masses m_j $(i = 1, 2, 3)$ $(j = 1, 2, \cdots, 8)$ of the perturbing planets, then the equations of motion are evaluated as

$$\ddot{x}^i = -k^2(1 + m)\frac{x^i}{r^3} + \sum_j k^2 m_j \left[\frac{x_j^i - x^i}{(\rho_j)^3} - \frac{x_j^i}{(r_j)^3}\right]$$

$$(i = 1, 2, 3), \qquad (j = 1, 2, \cdots, 8) \qquad \text{(A-28)}$$

where

$$r^2 = \sum_{i=1}^{3} (x^i)^2, r_j^2 = \sum_{i=1}^{3} (x_j^i)^2, \text{and } (\rho_j)^2 = \sum_{i=1}^{3} (x_j^i - x)^2$$

On option, the equations are modified for the relativity contribution by modifying Eq. (A-28) in the following form:

$$\ddot{x}^i + \frac{\mu x^i}{r^3} + c * x^i/r^4 = \frac{\partial R}{\partial x^i} \quad (i = 1, 2, 3) \qquad \text{(A-29)}$$

where $\mu = k^2(1 + m)$ and $\partial R/\partial x^i$ is the last term in the right hand side of Eq. (A-28). (This option is no longer in use, and will be replaced by equations in Ref. 10 in future versions of PLOD.)

c. Usage.

Calling sequence:

```
CALL DERIV (MTAPE, NOBOD, KPOS, XDS,
XDE, DM, XLITE, XMU, AKS, NAM, NREL,
XDSA, XH)
```

where

MTAPE = logical tape number of tape supplying COORD, the perturbing body tape.

NOBOD = the number of bodies on the COORD-EPHEM tape, which will be 10 (not used in this version).

KPOS = integer flag for COORD (when old version of COORD was used).
- KPOS = 1; position coordinates only from COORD.
- KPOS = 2; velocity coordinates only from COORD.
- KPOS = 3; position-velocity coordinates from COORD.

XDS = DP starting print date for DERIV if printing is desired.

XDE = DP end print date for DERIV if printing is desired.

DM = the DP masses of the main body and the Earth, with the main body and Earth set to zero before entering.

DM(1) = Mercury	DM(6) = Jupiter
DM(2) = Venus	DM(7) = Saturn
DM(3) = Earth–Moon	DM(8) = Uranus
DM(4) = Earth = 0.0	DM(9) = Neptune
DM(5) = Mars	DM(10) = Pluto

XLITE = DP value of the velocity of light supplied by the user in AU per day.

XMU = DP value of μ for the solar term.

AKS = DP value of the gravitational constant (squared) supplied by the user.

NAM = 1; print acceleration
= 2; no print
} print flag set by user.
Printing will occur only at time t, XDS $\leq t \leq$ XDE.

NREL = Relativity flag set by user.
= 1; relativity
= 2; no relativity.

XDSA = DP date set equal to zero by user before entering DERIV.

XH = DP step size of COORD-EPHEM tape computed by MAIN.

d. Storage.

The above quantities must be dimensioned as follows:

D DIMENSION XDS(1), XDE(1), DM(10), XLITE(1), XMU(1), AKS(1), XDSA(1), XH(1)

The subroutine reads from common storage the value of the DP Julian date and the position-velocity supplied by the user. It must be dimensioned and stored in common as follows:

DIMENSION DUMMY(4966), XL(1), XM(1), · · · , ZL(1), ZM(1), XL(1), XM(1), · · · , ZL(1), ZM(1), XJDL(1), XJDM(1)

DERIV, after computing $\ddot{X}^i$ $(i = 1,2,3)$, will store the value in common in the above location for the user.

e. Remarks.

The analytic relativity contribution is not included in this Report. The next version (PLOD III) will be published in the near future, and will contain this information.

f. Subroutines required.

DOUTPT DP precision library output routine.

14. EOSER

End of step test for TMAX. C. J. Devine, JPL.

Machine: IBM 7090/94, Language: Fortran II

a. Purpose.

This subroutine is called after every time step and tests for TMAX, indicating this by printing a statement that maximum time has been reached. EOSER then sets a flag for the end of integration.

b. Usage.

Calling sequence:

CALL EOSER (TMAX, J)

where

TMAX = DP end date supplied by user.

J = flag set by EOSER for MAIN program.

c. Storage.

Common storage:

DIMENSION DUMMY(4984), T2(1), T1(1)

where the current Julian date is obtained from T2, T1, the least and most significant parts of the DP number.

Storage for TMAX:

D DIMENSION TMAX(1)

15. ERRER

Error indication subroutine for FORTSZ. C. J. Devine, JPL.

Machine: IBM 7090/94, Language: Fortran II

a. Purpose.

This subroutine provides an error print routine for FORTSZ.

b. Method.

At any time FORTSZ indicates an error, ERRER is called and a summary of possible errors is printed. The integration is then stopped and the program is halted.

c. Usage.

Calling sequence:

CALL ERRER

16. FORDV

Driver for FORTSZ and subroutines used by FORTSZ. C. J. Devine, JPL.

Machine: IBM 7090/94, Language: FAP

a. Purpose.

FORDV acts as a logical link between PLODMN and its subroutines and the integration routine FORTSZ. It also computes the step size for FORTSZ.

b. Usage.

Calling sequence:

CALL FORDV (IFLAG, IFL, TS(2))

where

IFLAG = integer flag set by FORDV for calling of subroutines in PLODMN.

IFLAG = 1 CALL DERIV

IFLAG = 2 CALL TSTOP

IFLAG = 3 CALL EOSER

IFLAG = 4 CALL ERRER

IFLAG = 5 HALT

IFL = integer flag for FORTSZ to indicate whether velocity is desired at the time stop.
= 1; position-velocity computed by FORTSZ.
= 0; position only computed by FORTSZ.

TS(2) = most significant part of starting date supplied by user, i.e., user must set up the following instructions in his program (in this case the program PLODMN would have instructions):

TS(2) = XJD(1)
TS(1) = XJD(2)
DIMENSION TS(2),

D DIMENSION XJD(1), where TS is stored in common to insure an even location.

Several other quantities needed by FORTSZ are processed in FORDV. Because of the discrepancy between Fortran II and FAP, several integer constants are stored in common by PLODMN, shifted to B35 by FORDV, and restored in common. They are stored in the following order:

```
COMMON  BOOL  65652
     M  EQU   COMMON
     J  EQU   M + 1
     N  EQU   M + 2
OPTION  EQU   M + 3
 DTAPE  EQU   M + 4
     S  EQU   M + 5
    ES  EQU   M + 6
     H  EQU   M + 12
```

where quantities are those defined in the subroutine FORTSZ. H is the DP step size supplied by the user, and will remain constant for each integration. When FORTSZ calls the step size routine, FORDV simply gives it the value of H stored in common.

17. STPRG2

Double precision stepwise solution of normal equations. C. Lawson, W. Thomas, JPL, January 1, 1963.

Machine: IBM 7090, Language: Fortran II

a. Purpose.

This subroutine provides a DP solution of the normal equations of a linear least squares regression problem using the stepwise procedure of M. A. Efroymson.

The subroutine is particularly intended for use in least squares problems in which the user is aware of a large number of basic functions which might bear a linear relationship to the object function but expects that only some of these basic functions make a significant contribution to the determination of the object function.

b. Method.

In an n-parameter problem, this subroutine provides successively a 1-parameter fit, a 2-parameter fit, $\cdots$, a k-parameter fit, where the new parameter introduced at each step is the one which will make the greatest reduction in the sum of squares of residuals. This criterion is equivalent to the requirement that the new parameter be selected as the one which will have the highest statistical significance in the sense that the ratio of its magnitude to its standard deviation will be largest, or equivalently, its "F" value will be largest.* The termination level, k, which will be $\leq n$, is determined by the subroutine on the basis of tolerance parameters SDIN, SDOUT, and CD provided by the user.

For an exposition of this procedure, see Ref. 11. For a complete single precision regression package which incorporates this procedure in its system solving subroutine, see Ref. 12. Lawson also discusses the procedure, including details of its implementation in this program.*

c. Usage.

Let the overdetermined system of linear equations which expresses the linear regression problem be denoted by

$$\mathbf{Gc} = \mathbf{f}$$

where G is an m by n matrix ($m > n$), c is an n-vector, and f is an m-vector. The elements of G and f are known and the coefficient vector c is to be computed as a weighted least squares solution.

The normal equations $\mathbf{Ac} = b$ are formed from the overdetermined system by premultiplication by G*W (* denotes transposition), where W is an m by m nonnegative definite weighting matrix (W may be the identity matrix).

*Lawson, C. L., *Computation of the Most Significant Coefficients in Least Squares Estimation*, Jet Propulsion Laboratory Internal Document, August, 1932.

This computation, as well as the computation of the scalar quantity $s = f^*Wf$, is to be done by the user's program. STPRG2 may then be called as follows:

```
D DIMENSION A (6, 6), B (6), S (1)
  DIMENSION INOUT (6)
  CALL STPRG2 (A, B, S, N, M, SDIN,
  SDOUT, CD, NIN, INOUT, KPRINT)
```

The parameters are defined as follows:

A (I, J), I = 1, N; J = 1, N

On entry: The matrix **A**, computed by the user as $A = G^*WG$. On return: A^{-1} if NIN = N. If NIN < N, then only an NIN by NIN submatrix of **A** will have been inverted and the elements of this inverse will be in the locations **A (I, J)** corresponding to those values of I and J for which both INOUT (I) = +1 and INOUT (J) = +1. The other **A (I, J)** locations for $I \leq N$, $J \leq N$ will contain zero.

B (I), I = 1, N

On entry: The vector **b**, computed by the user as $b = G^*Wf$. On return: The solution vector **c** if NIN = N. If NIN < N, then only NIN components of **c** will have been computed and they will be those in the locations **B (I)** for which INOUT (I) = +1. The other **B (I)** locations for $I \leq N$ will contain zero.

S

On entry: The scalar s, computed by the user as $s = f^*Wf$. On return: The weighted sum of squares of residuals:

$$\begin{aligned}(f - Gc)^*W(f - Gc) &= (f - Gc)^*Wf \\ &= f^*Wf - (Gc)^*Wf \\ &= f^*Wf - c^*b\end{aligned}$$

N The dimension, n, of the normal system.

M The dimension, m, of the f vector.

SDIN, SDOUT. If SDIN > 0, these two numbers will be used by the "significance" logic of the program. A coefficient will be permitted to enter the solution if the ratio of its magnitude to its standard deviation will exceed SDIN. If this ratio subsequently drops below SDOUT, this coefficient will be removed from the solution. To avoid looping, SDIN should exceed SDOUT. Typical values for SDIN and SDOUT might be SDIN = 1.96, SDOUT = 1.64, which could be interpreted as meaning that a coefficient will be permitted to enter the solution if there is a 95% probability that it is different from zero and will later be removed from the solution if this probability falls below 90%.

If SDIN $\leq$ 0 all significance tests will be skipped. This permits use of the program with meaningless data in **B** and **S**, as may be the case when only matrix inversion is desired.

CD Tolerance for relative reduction in magnitude of diagonal elements. The ith coefficient will not be entered into the solution if the ith diagonal element becomes smaller than CD times the original ith diagonal element of the matrix **A**. If, e.g., CD = 10.** (−12), then a potential pivot element will not be used if it has lost more than its first 12 significant decimal places.

NIN On return: The number of coefficients in the final solution.

INOUT (I), I = 1, N On return: Flags to indicate final status of each coefficient:
- +1; included in solution.
- −1; rejected by diagonal test.
- −2; rejected by significance tests.

KPRINT Flag for control of printing:
- 0; no printing.
- 1; print summary, final solution only.
- 2; print summary, every solution.
- 3; full printing.

The summary printing is all single precision. Listed for each coefficient in the solution is its value, its standard deviation, and the ratio of these two quantities. Listed for each coefficient not in the solution is its predicted ratio of value to standard deviation or the word DEPENDENT if it has been rejected by the diagonal test. Also printed is the sum of squares of residuals and the unbiased estimate of the standard deviation of the residual function.

The full printing includes all of the summary plus the full augmented symmetric matrix* in DP for every solution.

d. Remarks.

The internal output of this subroutine, namely **A**, **B**, **S**, NIN, INOUT, was provided in case the user chose to incorporate this subroutine into a more complete regression package. For many applications this is not necessary and the user's program can ignore the internal output, employing the flag KPRINT to obtain the external output.

This subroutine uses storage rather extravagantly in that the given data is moved to locations which are local to the subroutine before processing and finally moved back to the user's storage locations. This could be changed if storage becomes a problem.

The first version of this subroutine was called STPREG. STPRG2 was written to provide more complete and flexible printing.

e. Storage.

$2947_{10} = 5603_8$ locations.

f. Subroutines required.

DOUTPT for DP output under the full printing option. Otherwise only standard Fortran II library subroutines are called.

18. ELEMTS

The DP calculation of the elements from the position-velocity coordinates at a given time. Specified and programmed by N. Block, JPL. Subroutine description by C. J. Devine, JPL.

Machine: IBM 7090/94; Language: Fortran II

a. Purpose.

This subroutine provides a DP transformation of the position-velocity coordinates at a certain time, t, to the elements a, n, e, i, Ω, ω, and M, where a is the semimajor axis, n is the mean motion, e is the eccentricity, i is the inclination, Ω is the longitude of the ascending node, ω is the argument of the perihelion, and M is the mean anomaly. The (3×3) direction cosine matrix **PQR** is also computed.

b. Method.

Given the DP position-velocity coordinates of the body, $X, Y, Z, \dot{X}, \dot{Y}, \dot{Z}$, the numerical value of Kepler's third law, $\mu = k^2(1 + m)$ (where m is the mass of the body), and the sine and cosine of the obliquity, then ELEMTS will compute the seven DP osculating elements of the orbit along with the direction cosine matrix **PQR**. The formulas and the explicit method used are outlined on pp. 48–49 of Ref. 3.

c. Usage.

Calling sequence:

CALL ELEMTS (COSOB, SINOB, DPOS, XMU, DPQR, ELEM, MEAN, XMEAN)

where

COSOB* = the DP value of the cosine of the obliquity supplied by the user for rotation to the ecliptic.

SINOB* = the DP value of the sine of the obliquity supplied by the user for rotation to the ecliptic.

DPOS = the DP position-velocity vector, supplied by the user DPOS (1) = X, $\cdots$, DPOS (4) = $\dot{X}$, $\cdots$, DPOS (6) = $\dot{Z}$.

XMU = the DP value of μ supplied by the user.

DPQR = the DP (3×3) **PQR** direction cosine matrix computed by ELEMTS, where (P_x, P_y, P_z) is the first column vector, (Q_x, Q_y, Q_z) is the second column vector, and (R_x, R_y, R_z) is the third column vector.

ELEM = the DP (7×1) osculating elements vector computed by ELEMTS in the order a, n, e, i, Ω, ω, and M.

MEAN = the mean motion integer flag supplied by the user. MEAN = 1; a is computed by the equations in Ref. 3, p. 48. MEAN = 2; a is computed from the DP XMEAN value of the mean motion supplied by the user.

XMEAN = the DP value of the mean motion supplied by the user (used primarily when the mean motion is held fixed in PLOD II).

d. Storage.

The quantities in the calling sequence must be dimensioned as follows:

D DIMENSION COSOB(1), SINOB(1), DPOS(6), XMU(1), DPQR(3,3), ELEM(7), XMEAN(1).

e. Subroutines required.

ARCTN (Section 21).

*If no rotation is desired, i.e., if the position-velocity coordinates are in the equatorial system and equatorial elements are desired, or if they are in the ecliptic system and ecliptic elements are desired, then setting COSOB = 1, and SINOB = 0 will suppress the rotation.

19. OBLIQ

The DP computation of the angle of the obliquity. Specified and programmed by N. Block, JPL. Subroutine description by C. J. Devine, JPL.

Machine: IBM 7090/94, Language: Fortran II

a. Purpose.

This subroutine computes the angle of the obliquity given the Julian date.

b. Method.

Evaluation of polynomials in T, the Julian date.

c. Usage.

Calling sequence:

CALL OBLIQ (XJD, EPSLN)

where

XJD = DP value of Julian date supplied by the user.

EPSLN = DP value of obliquity, computed by OBLIQ, which must be multiplied by 2π by the user.

d. Storage.

D DIMENSION XJD(1), EPSLN(1)

e. Subroutines required.

None required.

20. SPHER

The DP solution of spherical coordinates. Specified and programmed by N. Block, JPL. Subroutine description by C. J. Devine, JPL.

Machine: IBM 7090/94, Language: Fortran II

a. Purpose.

This subroutine computes the radius vector, the longitude, and the latitude given the position coordinates x, y, z.

b. Method.

Given x, y, z in DP, then ρ, λ, and β are found by the usual trigonometric relations. An interval reduction is also performed, with tests for zero values.

c. Usage.

Calling sequence:

CALL SPHER $(x, y, z, \rho, \lambda, \beta)$

where

x, y, z = the DP values of the position coordinates supplied by the user.

ρ = the DP value of the radius vector computed by OBLIQ.

λ = the DP value of the longitude computed by OBLIQ.

β = the DP value of the latitude computed by OBLIQ.

d. Storage.

D DIMENSION $x(1), y(1), z(1), \rho(1), \lambda(1), \beta(1)$

e. Subroutines required.

ARCTN (Section 21).

21. ARCTN

Interval reduction of the argument for calling the inverse tangent function. Specified and programmed by N. Block, JPL. Subroutine description by C. J. Devine, JPL.

Machine: IBM 7090/94, Language: Fortran II

a. Purpose.

This subroutine provides interval reduction of the argument for calling the inverse tangent function. The function subroutine also tests for zero, negative, or positive x and y for an expression of the type Arctangent (y, x).

b. Method.

Sets up the interval reduction logic and calls the Fortran II library subroutine ATANF (Y/X) and returns the value of the function in a function type statement.

c. Usage.

Calling sequence:

VALUE = ARCTN (Y, X)

where ARCTN is defined in the function subroutine as ARCTN = ATANF(Y/X).

d. Subroutines required.

Fortran library function ATANF.

22. RUN

Rewind and unload tapes. Programmer: G. Orozco. Machine: IBM 7094

a. Purpose.

This subroutine rewinds and unloads tapes by a Fortran II type calling sequence.

b. Usage.

Calling sequence:

CALL RUN

23. DPINPT

DP input.

a. Purpose.

This subroutine reads DP decimal information from a BCD tape, converts to binary and stores the results in core storage.

b. Restrictions.

Input is from tape A2 (logical tape 5) and is limited to a complete singly subscripted array (i.e., if X is dimensioned $X(20)$, then all 20 values of X must be computed at once). Only the first 17 significant digits are converted.

c. Usage.

Calling sequence:

CALL DPINPT $(X, N, \cdots)$

where

X is the location of an array to start storing DP numbers.

N is the number of DP numbers to be stored sequentially starting at X (and the dimension of X).

The number of arguments in the calling sequence is variable, consisting of ordered pairs (X, N).

Example: CALL DPINPT $(X, 10, Y, 3, Z, 1, A, 2, \cdots)$

This would cause the subroutine to read in 10 DP numbers and store them in array X (the Fortran program could refer to them as $X(1), X(2), \cdots, X(10)$ in any statement in the DP mode). Then the subroutine would read in three DP numbers and store them in $Y(1)$, $Y(2)$, $Y(3)$, and then one number in Z, and then two numbers in $A(1)$, $A(2)$, etc.

Data card format:

Each card must have DEC in columns 8, 9, 10, with a blank in column 11. The data field starts in column 12.

Several numbers may appear on one card separated by commas, but the first number called for by a new pair of arguments (X, N) must start a new card.

E-type numbers are permissible, i.e., 0.100, 1.0E-01 are equivalent.

Space required:

$1331_{(8)}$ or $729_{(10)}$.

24. DOUTPT

DP output.

a. Purpose.

This subroutine outputs DP numbers in a fixed format.

b. Restrictions.

Output is to tape A3.

c. Usage.

Calling sequence:

CALL DOUTPT $(X, N, I, Y, M, J, \cdots)$

Each triplet of arguments is examined separately. The first number of the triplet, X, is the name of the array to be written on tape for printing. The second, N, is the name of a fixed-point variable or constant indicating the number of double precision numbers to be outputted from the array X. The third, I, is the product of the dimensions of X.

If N is positive, N double precision numbers $X(1)$ through $X(N)$ will be written on tape A3 for printout in floating point form, four to a line, ending in columns 30, 60, 90 and 120. The numbers when printed out are in the following form:

SX.XXXXXXXXXXXXXXXXPEE

where

X is the characteristic.

S is the sign of the number either blank (for positive) or − (for negative).

P is the sign of the exponent either blank (for positive) or − (for negative).

E is the exponent.

If N is negative, the numbers will be printed in a fixed-point format, four to a line ending in columns 30, 60, 90 and 120. The format would be similar to using a Fortran format 4F30.12 (except, of course, the Fortran format would not give the results with the DP accuracy).

Each new triplet (X, N, I) begins a new line.

Accuracy:

The output is correct to 17 significant decimal digits.

Storage requirements:

$1566_{(8)}$ or $886_{(10)}$.

APPENDIX II. SAMPLE OF PLOD II OUTPUT

```
HEIGHT  FACTOR

      1.0000000000000000 00          1.0000000000000000 00          1.0000000000000000 00

E9604    ON  CHAN 86
E9065    ON  CHAN A6

BCD  FROM  SOURCE  TAPE  HEADING

SOURCE TAPE-JUPTER FROM AP.VOL.12 AND AP.VOL.13,PT.5*USING DATA FROM TA
PES N-6542,N-6137 WRITING OUTPUT ON N-6601 WITH NXB025 DATE 09/29/63

COMPUTED  MASSES  WITH  MAIN  BODY  AND EARTH  SET  TO  ZERO

      1.6666666666666666-07          2.4509803921568626-06          3.0359149729469625-06          0.0000000000000000 00
      3.2325844512687894-07          0.0000000000000000 00          2.8558373315055975-04          4.3727316454589180-05
      5 1775913844879362-05          2.7777777777777777-06


DEPSIL                    0.09999999E-10
MEAN  MOTION  INPUT        0.10361496E-03
MEAN                       1
KAN                        2
LAN                        1
KAN                        1
MAN                        3
NSTEP                      3
NPPINT                     4
JAN                        1
NEPHN                      0
NTEST                      2
ITRMAX                     8
NEPOCH                     3
NECLPT                     2
NREL                       2
JEND                       0


FIRST  RECORD  BCD  RESIDUAL  TAPE  HEADING
PRE-CONVERGED PLODII RESIDUAL TAPE,IN USUAL FORMAT,WILL BE (N-1) FILES
OF INFO CORRESP. TO (N-1) ITERATIONS FOR THE PLANET          JUPITER
END OF RECORD
BODIES 1.0 TAPE TYPE 4.0 START 2433280.5 TMAX 2437840.5 STEP SIZE 40.0 BODY NO. 5.0 STEP SIZE 40.0

 INPUT  DATA  FROM  SOURCE  TAPE  EPOCH

      3.3493566767910812 00         -3.4737659859436163 00         -1.5721611877552956 00
      5.5058657700590086-03          4.9622465647199965-03          1.9922578737078313-03

 END  OF  INPUT  DATA


 MEAN  MOTION  IS  COMPUTED
```

```
BEGIN  ITERATION


EPOCH  VALUES  EQUATORIAL    2433280.50

      3.3493566767918812 00        -3.4737659590436103 00        -1.5721611877352956 00
      5.5858657700059086-03         4.9622465647199965-03         1.9922578737076313-03

ELEMENTS  CHECK  FROM  SUBR  ELEMTS

      5.2028657014285056 00         1.4501894721101014-03         4.8913780375478132-02        4.05F469884336925E-01
      5.6931813444923797-02         1.8568722945840124-01         5.2805235197808140 00

TRANSPOSE  PQR  MATRIX  CHECK

      9.7156544465614131-01         2.2527293087.18986-01         7.2888225140388591-02
     -2.3570307304279314-01         8.9100618067075155-01         3.8801037017675749-01
      2.2464374202254042-02        -3.9415744648619983-01         9.1876833819585918-01

ECLIPTIC  ELEMENTS

      5.2028657014285056 00         1.4501894721101014-03         4.8913780375478132-02        2.2814293602892913-02
      1.7446796417665389 00         4.7764645083882447 00         5.2805235197808140 00

ECLIPTIC  PQR  MATRIX

      9.7156544465614131-01         2.3567476463610928-01        -2.2761509916862849-02
     -2.3570307304279314-01         9.7182402132756995-01         1.4604550299793795-03
      2.2464374202254042-02         3.9460301938964437-03         9.9973985653139297-01

ECLIPTIC  EPOCH  POS-VEL     2433280.5

      3.3493566767918792 00        -3.8124946131893180 00        -4.0212646793349259-02
      5.5858657700059086-03         5.3452302914440853-03        -1.4861355958427743-04

EPOCH  VALUES  EQUATORIAL    2433280.50

      3.3493566767918792 00        -3.4737659590436092 00        -1.5721611877352948 00
      5.5858657700059086-03         4.9622465647199691-03         1.9922578737076283-03
```

```
EPHEMERIS  FORMAT  FOR  EACH  JULIAN  DATE  IS

JUL-DATE    EQUA. X      EQUA. Y      EQUA. Z      X      XDOT    EQUA XDOT  EQUA YDOT  EQUA ZDOT        XPFDX          XPFDY          XPFDZ
            ECLP. X      ECLP. Y      ECLP. Z      E...   YDOT    ECLP XDOT  ECLP YDOT  ECLP ZDOT        XPFDR          XPFCOSBDL      XPFDB

2433280.5 3.34935665-3.47376594-1.57216118 0.00558586 0.00496224 0.00199226          0.0000         -0.0000         -0.0000
          3.34935665-3.81249461-0.0 021264 0.00558586 0.00534523-0.00014661          0.0000          0.0000         -0.0000
2433320.5 3.56657150-3.26908217-1.4 966375 0.00527120 0.00526898 0.00213154         -84.3962          1.0397          3.3.6
          3.56657150-3.59189054-0. 96429 0.00527120 0.00568206-0.00014087         -12.0733         -11.5119          0.3684
2433360.5 3.77076423-3.05247271-1.40172754 0.00493490 0.00555879 0.00226409        -168.9852          2.3981          6.8550
          3.77076423-3.35817230-0.07147519 0.00493490 0.00600068-0.00013457         -25.6511         -21.5266          0.4934
2433400.5 3.96108758-2.82462868-1.30863467 0. 9457791 0.00583022 0.00238927        -254.0955          4.5323         10.4649
          3.96108758-3.11209986-0.07672319 0.00457791 0.00 .3950-0.00012773         -40.7108         -29.8461          0.9698
2433440.5 4.13673657-2.58631802-1.21049272 0.00420137 0.00608189 0.00250644        -340.0198          7.8135         15.0693
          4.13673.57-2.85449558-0.08168695 0.00420137 0.00657701-0.00012095         -57.1905         -36.2606          1.2019
2433480.5 4.29695386-2.33035927-1.10823426 0.00380657 0.00631240 0.00241498        -427.2735         12.9093         20.1684
          4.29695386-2.58624277-0.08434590 0.00380657 0.00683169-0.00011250         -75.0511         -43.9488          1.3810
2433520.5 4.44103903-2.08162367-1.001616 5 0.00339501 0.00652055 0.00231434        -516.5114         19.7127         26.1222
          4.44103903-2.30828764-0.09068067 0.00339501 0.00706217-0.00010416         -94.2187         -42.5374          1.5141
2433560.5 4.56835175-1.81702858-0.89121604 0.00298821 0.00670519 0.00220399        -608.4359         28.8127         33.0722
          4.56835175-2.02160725-0.09467304 0.00298821 0.00726723-0.00009538         -114.5124        -42.0610          1.6068
2433600.5 4.67831582-1.54853648-0.77743228 0.00252785 0.00686534 0.00208346        -704.0503         40.2196         41.0764
          4.67831582-1.72725612-0.09830601 0.00252785 0.00744579-0.0000861.        -136.1697         -36.8742          1.6637
2433640.5 4.77042149-1.26813.45-0.66068042 0.00207558 0.00700003 0.00195230        -804.3537         53.8852         50.1416
          4.77042145-1.42631139-0.10156376 0.00207558 0.00759675-0.00007663         -158.8030         -32.9182          1.6938
2433680.5 4.84422952-0.98588313-0.54139553 0.00161330 0.00710838 0.00181009        -910.3643         69.7447         60.2528
          4.84422952-1.11989671-0.10443191 0.00161330 0.00771919-0.00006672         -182.4139         -23.9995          1.7052
2433720.5 4.89937842-0.69982991-0.42002548 0.00114296 0.00718971 0.00167648        -1023.1137        87.3620         71.2327
          4.89937847-0.80917005-0.10689773 0.00114296 0.00781222-0.00005652         -206.8772         -12.0146          1.7071
2433760.5 4.93558627-0.41107356-0.29703262 0.00066840 0.00724347 0.00309119        -1143.6739        104.1726        82.8948
          4.93558627-0.49931774-0.10895026 0.00066840 0.00787535-0.00004607         -232.0720         3.1312          1.7180
2433800.5 4.95265400-0.12072404-0.17288838 0.000141 9 0.00726932 0.00311402        -1273.0669        125.5714        99.0031
          4.95265400-0.17954573-0.11058033 0.00016629 0.00790819-0.00003341         -257.8676         21.5410         1.7518
2433840.5 4.95046353 0.17009612-0.04807130-0.00029594 0.00726607 0.00312480        -1412.3839        144.7977        107.2418
          4.95046353 0.13692574-0.11178052-0.00029594 0.00791028-0.00002457         -281.1448         43.3008         1.7880
2433880.5 4.92898035 0.46025586 0.07693396-0.00077800 0.00723628 0.00312362        -1564.6318        162.8875        114.2156
          4.92898035 0.4528643.-0.1 .256509-0.00077800 0.00788159-0.00001363         -310.7805         68.4741         1.8366
2433920.5 4.88825488 0.74862044 0.20163981-0.00129769 0.00717725 0.00310982        -1724.8978        178.8435        120.8218
          4.88825488  .76704092-0.11287028-0.00.29769 0.00782199-0.00000262         -337.6192         97.1340         2.1180
2433960.5 4.82842666 1.03405900 0.32555727-0.00173277 0.00709902 0.00308402        -1899.2591        191.1644        140.5124
          4.82842666 1.07821704-0.11275434-0.00173277 0.00773172 0.00000841         -364.5320         129.2560        2.3746
2434000.5 4.74972320 1.31548255 0.44820093-0.00220110 0.00697506 0.00304615        -2087.0726        198.2826        148.3698
          4.74972320 1.38517350-0.11219771-0.00220110 0.00761119 0.00001941         -391.3899         164.8268        2.7280
2434040.5 4.65245748 1.59170233 0.56909163-0.00266055 0.00683295 0.00299641        -2288.6979        198.6117        155.9065
          4.65245748 1.68671739-0.11120272-0.00266055 0.00746102 0.00003032         -416.0768         203.8875        3.1838
```

STPRGZ STEPWISE REGRESSION PROGRAM

N	MTOTAL	SDIN	SDOUT	FIXC
6	29	10.000000E-10	0.	10.000000E-09

NO. OF COEFFS IN REGRESSION = 0 SUM OF SQUARED RESIDUALS = 1.13903E-08 S.D. OF DATA = 2.38645E-05

COEFFS IN REGRESSION

INDEX	COEFF	S.D.	COEFF/S.D.

COEFFS NOT IN REGRESSION

INDEX	PREDICTED (COEFF/S.D.)
1	4.1469E-01
2	1.2354E-02
3	2.4416E-02
4	-4.3264E-01
5	4.3171E 00
6	3.2942E 00

INTRODUCING COEFF NO. 5

NO. OF COEFFS IN REGRESSION = 1 SUM OF SQUARED RESIDUALS = 6.15521E-09 S.D. OF DATA = 1.80647E-05

COEFFS IN REGRESSION

INDEX	COEFF	S.D.	COEFF/S.D.
5	-1.10225736-05	2.7439E-06	-4.0171E 00

COEFFS NOT IN REGRESSION

INDEX	PREDICTED (COEFF/S.D.)
1	3.1439E 00
2	1.0361E-02
3	3.9232E-02
4	5.7976E 00
6	3.6654E 00

INTRODUCING COEFF NO. 4

NO. OF COEFFS IN REGRESSION = 2 SUM OF SQUARED RESIDUALS = 2.14007E-09 S.D. OF DATA = 1.59242E-05

COEFFS IN REGRESSION

INDEX	COEFF	S.D.	COEFF/S.D.
4	1.39047C2E-05	2.2431E-06	5.3976E 00
5	-2.4623776E-05	2.8767E-06	-8.5597E 00

COEFFS NOT IN REGRESSION

INDEX	PREDICTED (COEFF/S.D.)
1	7.1994E 01
2	2.6887E-02
3	5.7915E-02
6	7.3149E 00

INTRODUCING COEFF NO. 1

NO. OF COEFFS IN REGRESSION = 3 SUM OF SQUARED RESIDUALS = 7.02225E-12 S.D. OF DATA = 8.42750E-07

COEFFS IN REGRESSION

INDEX	COEFF	S.D.	COEFF/S.D.
1	4.15965006-05	5.7777E-07	7.1995E 01
4	4.3538445E-05	4.4417E-07	9.8022E 01
5	-3.6919766E-05	2.4C45E-07	-1.5355E 02

COEFFS NOT IN REGRESSION

INDEX	PREDICTED (COEFF/S.D.)
2	4.5791E-01
3	1.0138E 00
6	1.5019E 01

INTRODUCING COEFF NO. 6

NO. OF COEFFS IN REGRESSION = 4 SUM OF SQUARED RESIDUALS = 4.65131E-13 S.D. OF DATA = 1.70531E-07

COEFFS IN REGRESSION

INDEX	COEFF	S.D.	COEFF/S.D.
1	3.7992999E-05	2.8477E-07	1.3342E 02
4	4.46984578-05	1.4009E-07	3.1726E 02
5	-4.04106106-05	2.4103E-07	-1.6766E 02
6	-3.0952638E-06	2.0609E-07	-1.5019E 01

COEFFS NOT IN REGRESSION

INDEX	PREDICTED (COEFF/S.D.)
2	1.9072E 00
3	1.2627E 01

INTRODUCING COEFF NO. 3

NO. OF COEFFS IN REGRESSION = 5 SUM OF SQUARED RESIDUALS = 4.37040E-14 S.D. OF DATA = 5.39778E-08

COEFFS IN REGRESSION

INDEX	COEFF	S.D.	COEFF/S.D.
1	3.7992100E-05	9.0152E-08	4.2142E 02
3	-1.7258604E-07	1.4350E-08	-1.2027E 01
4	4.4698433E-05	4.4504E-08	1.0021E 03
5	-4.0410579E-05	7.6306E-08	-5.2959E 02
6	-3.0952236E-06	6.5248E-08	-4.7439E 01

COEFFS NOT IN REGRESSION

INDEX	PREDICTED (COEFF/S.D.)
2	2.4307E 01

INTRODUCING COEFF NO. 2

NO. OF COEFFS IN REGRESSION = 6 SUM OF SQUARED RESIDUALS = 1.01160E-15 S.D. OF DATA = 8.50C43E-09

COEFFS IN REGRESSION

INDEX	COEFF	S.D.	COEFF/S.D.
1	3.79921008-05	1.4197E-08	2.6760E 03
2	1.1859301E-07	4.8773E-09	2.43C7E 01
3	-2.2545041E-07	3.1364E-09	-7.1881E 01
4	4.4698430E-05	7.0242E-09	6.3635E 03
5	-4.0410577E-05	1.2017E-08	-3.3629E 03
6	-3.0952222E-06	1.0275E-08	-3.0124E 02

COEFFS NOT IN REGRESSION

INDEX	PREDICTED (COEFF/S.D.)

LITTLE OMEGA TILTA

9.1381930348343331-04

THIS IS PQR MATRIX

9.7156544465614131-07	6.3567456463610928-01	-2.2741509916862849-02
-2.3570307304279314-01	9.7182402132756995-01	1.4604550299793795-03
2.2444374202254042-02	3.9460301938944637-03	9.9973985653139297-01

ELLPTS

9.2028657014285056 00	1.4501894721101:14-03	4.8913780375478132-02	2.2810293662892913-02
1.7446796417665389 00	4.7766465583682447 00	5.2805235197868183 00	

```
XSOLVE

    3.7992101522527726-05        1.1855305089412727-07       -2.2545066800712488-07        4.4496431015933324-05
   -6.0416577915250950-05       -2.0952222253861745-06
NEW  PCR

    9.7134965371524473-01        2.3656254602886904-01       -2.2759946318647660-02
   -2.3659378058074201-01        9.7160825175026323-01        1.4813726738695742-03
    2.2464183104942974-02        3.9458618494427453-03        9.9973986145902397-01
ELLIPTICAL  CORRECTIONS

   -2.1025580981926499-04        0.0000000000000000 00       -5.0952222250861745-06       -2.1739688237182471-07
   -5.8206572523636943-06        9.1963936573573699-04       -8.7582872151099168-04
NEW    ELEMENTS

    5.2026554950186953 00        1.4502773412426911-03        4.8910465153253845-02        2.2810076266090541-02
    1.7446738217092883 00        4.7773841477339793 00        5.2796476910593089 00
KEPLERS  J  RC  LAN  PU

    2.9619474115807876-04

                 ****************************************

     PLCO  HAS  EXCEEDED  TOLERANCES .IT  WILL  NOW  CORRECT

     EPOCH  VALUES  AND  BEGIN  A  NEW  ITERATION.

     JULIAN  DATE.....  2434642.50

     ELAPSED  TIME  IN  DAYS,.....  760.00

     NUMBER  OF  INTEGRATION  STEPS..  20.

     SIGMA.....  6.23864684E-04

     SIGMA  SQUARE  X  N.....  0.113932538-07

     X  =  4.64245748  Y  =  1.59179233  Z  =  0.58909163


 **** STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....      DELTA  X         DELTA  Y         DELTA  Z
MEAN  DEVIATION  .....MD=SUM(DELTA)/N    -6.961649108-06  0.8173353J3E-05  6.357989818-05
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  6.13797149E-07  8.120159908E-09  8.690311898E-10
STANDARD  DEVIATION.....SD=SQRT(SR-MD**2)  0.674469558-04  0.733453298-05  9.519113231E-05
MAXIMUM  RESIDUAL  .....  0.244249368-04  0.198411748-04  0.153904588-04
MINIMUM  RESIDUAL  .....  -6.228863798-03  -0.155431228-14  -0.999280728-15

 **** STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....  RADIUS VECTOR       COSB  DL        DLAT=DB
MEAN  DEVIATION  .....MD=SUM(DELTA)/N    -6.185012838-06  0.199712138-05  0.166079398-06
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  0.51286637E-09  3.566152888-10  0.310138498-11
STANDARD  DEVIATION.....SD=SQRT(SR-MD**2)  0.136602368-04  0.725443278-05  0.723031528-07
MAXIMUM  RESIDUAL  .....  0.5842297BE-15  0.203827468-04  0.318380068-06
MINIMUM  RESIDUAL  .....  -4.415076818-24  -0.425376138-05  -2.517986858-16

 ECLIPTIC  PCS-VEL  FROM  TRANSX AND EQUATORIAL  POS-VEL  AFTER  ROTATION  FROM  ECLIPTIC

      3.3495568901487465 00       -3.8124944908035363 00       -6.0212659531310934-02
      5.5856551063767422-03        5.3452353148799887-03       -1.4462687717959939-04
      3.3495568901487465 00       -3.4737658441521053 00       -1.5721611452525865 00
      5.5856551003767422-03        4.9622485145825023-03        1.9922660031696155-03

 BEGIN  ITERATION


 EPOCH  VALUES  EQUATORIAL    2433207.50

      3.3495568901487465 00       -3.4737658441521053 00       -1.5721611452525865 00
      5.5856551003767422-03        4.9622485145825023-03        1.9922660031696155-03

 ELEMENTS  CHECK  FROM  SUBR  ELEMTS

      5.2026554950186442 00        1.4502773813426450-03        4.8910465153251036-02        4.0584714657066356-01
      5.6931307665872135-02        1.9660151499311345-01        5.2796476910592482 00

 TRANSPOSE  FOR  MATRIX  CHECK

      9.7134965371523124-01        2.2603859677998126?-01        7.3242V738699541S2-02
     -2.3659085085803976?-01        8.9079993293200650-01        3.8794371013279694-01
      2.2464183104942873-02        -3.9419760297448796-01        9.1876027576381404-01

 ECLIPTIC  ELEMENTS

      5.2026554950186442 00        1.4502773813426450-03        4.8910465153251036-02        2.2810076266090931-02
      1.7446738217092894 00        4.7773841477340322 00        5.2796476910592482 00

 ECLIPTIC  PCR  MATRIX

      9.7134965371523124-01        2.3656254002692431-01       -2.2759960318647545-02
     -2.3659388058039766-01        9.7160825173022913-01        1.4813726738707733-03
      2.2464183104942873-02        3.9458618494427333-03        9.9973960148981191-01
```

EPHEMERIS FORMAT FOR EACH JULIAN DATE IS

JUL-DATE	EQUA. X ECLP. X	EQUA. Y ECLP. Y	EQUA. Z ECLP. Z	EQUA XDOT ECLP XDOT	EQUA YDOT ECLP YDOT	EQUA ZDOT ECLP ZDOT	TPFDX TPFDP	TPFDY TPFCOSOBL	TPFDZ TPFDR
2433280.5	3.34775689 3.34935689	-3.47316582 -5.81244449	-1.57216114 -0.68021265	0.00958565 0.00958565	0.00496224 0.00534523	0.00199226 -0.00014461	-2.1336 -0.2946	-1.1489 -0.4749	-0.4248 0.0121
2433320.5	3.36656328 3.36656328	-3.26980696 -3.57188027	-1.48966338 -0.68596403	0.00927099 0.00927099	0.00526898 0.00568207	0.00213154 -0.00014887	-2.2377 -0.1689	-2.9961 -0.4554	-0.9930 0.0080
2433360.5	3.37574757 3.37874757	-3.35147238 -3.13817178	-1.46172683 -0.67147468	0.00895868 0.00895868	0.00555880 0.00620069	0.00228418 -0.00013456	-7.3595 -0.2284	-2.8437 -0.4443	-0.3128 0.0091
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2433440.5	4.13679284 4.13670264	-2.5863.715 -2.83444415	-1.21649118 -0.52168569	0.00420115 0.00420115	0.00600190 0.00657703	0.00250645 -0.00012836	-2.4906 -3.3537	-0.9024 -0.4571	-0.3903 0.0112
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2433520.5	4.44698765 4.44698765	-2.08161162 -2.33627972	-1.00161341 -0.09067907	0.00339478 0.00339478	0.00652056 0.00720210	0.00271436 -0.00010415	-2.8218 -0.4187	-0.8493 -0.4172	-0.2713 0.0102
2433560.5	4.56829119 4.568.9119	-1.81703563 -2.02166322	-0.89121271 -0.99442115	0.00296756 0.00296756	0.00670522 0.00728728	0.00280401 -0.00009537	-2.7618 -0.4432	-0.7484 -0.3855	-0.2214 0.0104
2433600.5	4.67826572 4.6782965.2	-1.54553039 -1.72125076	-0.77252818 -0.84803383	0.00252761 0.00252761	0.00686537 0.00744583	0.00288348 -0.00008619	-2.7407 -0.4764	-0.6427 -0.3818	-0.1662 0.0102
2433640.5	4.77034128 4.77334128	-1.26613963 -1.42835446	-0.64867979 -0.72156132	0.00207533 0.00207533	0.00700867 0.00759479	0.00295232 -0.00007662	-2.8079 -0.5105	-0.5935 -0.2353	-0.1343 0.0105
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2433920.5	4.88805288 4.88805288	0.74843847 0.76706244	0.20149282 -0.11288344	0.00125811 0.00125811	0.00717726 0.00782204	0.00310984 -0.00000311	-4.2431 -0.8267	0.5911 0.2648	0.3900 0.0091
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2434000.5	4.74951586 4.74951586	1.31547228 1.38519949	0.44821573 0.11219199	0.00227158 0.00227158	0.00697588 0.00761121	0.00296417 0.00001942	-4.6982 -0.8478	0.9793 0.4554	0.5871 0.0189
2434040.5	4.63222913 4.63222913	1.90172267 1.98674161	0.54912694 0.23119651	0.00263294 0.00263106	0.00683294 0.00746101	0.00285453 0.00003033	-5.2949 -0.8739	1.1949 0.6107	0.6845 0.0312
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-5.97813936-1.98527622 0.12191647 0.00266434-0.0066772B-0.00003353	0.6780	1.9343	-0.0162
2436280.5-4.98419626-2.11135461-0.78-41279 0.00303151-0.00596718-0.00263406	0.6383	-9.8709	-4.3132
-4.98419626-2.24913764 0.12041892 0.00303151-0.00652753-0.00004236	0.7085	1.8483	-0.0211
2436320.5-4.83572918-2.34683439-0.88857573 0.00339037-0.00583991-0.00257279	0.8643	-9.5632	-4.1930
-4.83572918-2.50662017 0.11854905 0.00339037-0.00634439-0.00005111	0.7412	1.7753	-0.0255
2436360.5-4.69309074-2.57543546-0.99013394 0.00373991-0.00562329-0.00250385	1.3666	-9.3248	-4.0864
-4.69309074-2.75-75532 0.11633135 0.00373991-0.00615525-0.00005972	0.7779	1.7117	-0.0298
2436400.5-4.53667194-2.79.47222-1.08878383 0.00407925-0.00542574-0.00242746	1.3480	-9.0485	-3.9729
-4.53667194-2.99.79357 0.11377317 0.00407925-0.00594264-0.00006818	0.7947	1.6522	-0.0349
2436440.5-4.38689764-3.1[illegible]27615-1.18422822 0.00443753-0.00521171-0.00234360	1.7137	-8.6947	-3.8424
-4.38689764-3.34140337 0.11087959 0.00443753-0.00571389-0.00006744	0.7873	1.5944	-0.0378
2436480.5-4.18422824-3.21319535-1.27617841 0.00472387-0.00498159-0.00225262	2.0353	-8.2559	-3.6519
-4.18422824-3.45567074 0.10765858 0.00472387-0.00546457-0.00008455	0.7896	1.5 11	-0.0473
2436520.5-3.93915923-3.40759489-1.36434395 0.00[illegible]2735-0.00473581-0.00215460	2.3484	-7.8096	-3.4697
-3.98915923-3.66910022 0.10411843 0.00502735-0.00520208-0.00009241	0.7479	1.4555	-0.0284
2436560.5-3.78222424-3.59135922-1.44865334 0.00531702-0.00447493-0.00204976	2.5390	-7.2827	-3.2355
-3.78222424-3.87161672 0.10022866 0.00531702-0.00492103-0.00010003	0.7247	1.3842	-0.0265
2436600.5-3.56599241-4.76539400-1.52823676 0.00559204-0.00419953-0.00193833	2.5722	-6.7753	-2.9904
-3.56599241-4.08257010 0.09811934 0.00559204-0.00442403-0.00010738	0.7134	1.2691	-0.0215
2436640.5-3.33556742-3.92763650-1.60345537 0.00585155-0.00391023-0.00182054	2.5957	-6.2311	-2.7782
-3.33556742-4.24133563 0.09186196 0.00585155-0.00431176-0.00011444	0.6981	1.1595	-0.0267
2436680.5-3.09863515-4.07633720-1.67380138 0.00609477-0.00350763-0.00163869	2.5369	-5.7861	-2.5955
-3.09863513-4.40731567 0.08696796 0.00609477-0.00388485-0.00012119	0.6954	1.0579	-0.0259
2436720.5-2.84771481-4.21607816-1.73969257 0.00632080-0.00320236-0.00156496	2.4439	-5.4784	-2.4588
-2.84771481-4.55993810 0.08199039 0.00632080-0.00364460-0.00012762	0.7061	0.9770	-0.0249
2436760.5-2.59066069-4.34126717-1.7994[illegible]353 0.00[illegible]2-0.00296515-0.00143167	2.4260	-5.2036	-2.3495
-2.59366069-4.69866043 0.07676282 0.00[illegible]2-0.00328998-0.00013369	0.7131	0.9096	-0.0261
2436800.5-2.32566133-4.45331625-1.85355687 0.00[illegible] -0.00282681-0.00129114	2.4208	-4.9100	-2.2179
-2.32566133-4.82297268 0.07129988 0.00671703-0.00292365-0.00013939	0.7095	0.8442	-0.0246
2436840.5-2.05348757-4.55127555-1.90231037 0.00696743-0.00227822-0.00114574	2.4727	-4.4891	-2.0297
-2.05348757-4.93240196 0.06561708 0.00688743-0.00254663-0.00010448	0.6730	0.7816	-0.0225
2436880.5-1.77493778-4.63527513-1.94515619 0.00703641-0.00192025-0.00099581	2.5491	-3.9995	-1.8178
-1.77493778-5.02651376 0.05973562 0.00703641-0.00215703-0.00014956	0.6175	0.7252	-0.0213
2436920.5-1.49083786-4.70478320-1.98192078 0.00716484-0.00155380-0.00084174	2.4979	-3.5197	-1.5998
-1.49083786-5.10491047 0.05365738 0.00716484-0.00176342-0.00013402	0.5659	0.6546	-0.0184
2436960.5-1.20223927-4.75947732-2.01244500 0.00727140-0.00117971-0.00068386	2.3971	-3.1094	-1.4183
-1.20223927-5.16723436 0.04741506 0.00727140-0.00135441-0.00015801	0.5248	0.5860	-0.0160
2437000.5-0.90942392-4.79907250-2.03658500 0.00735558-0.00079903-0.00052261	2.1642	-2.7175	-1.2585
-0.90942392-5.21316528 0.04122332 0.00735558-0.00094100-0.00016154	0.4869	0.5001	-0.0176
2437040.5-0.61389919-4.82332665-2.05421466 0.00741676-0.00041284-0.00035842	1.8704	-2.4610	-1.1378
-0.61389919-5.24243146 0.03449850 0.00741676-0.00052137-0.00016456	0.4687	0.4117	-0.0153
2437080.5-0.31619965-4.83204234-2.06522638 0.00745440-0.00002231-0.00019179	1.4906	-2.2234	-1.0263
-0.31619965-5.25482898 0.02786374 0.00745440-0.00009678-0.00016708	0.4449	0.3485	-0.0152
2437120.5-0.01786525-4.82506925-2.06953257 0.00746807 0.00037140-0.00002322	1.5496	-2.0487	-0.9455
-0.01786525-5.25312487 0.02113859 0.00746807 0.00033150-0.00016908	0.4286	0.2966	-0.0117
2437160.5 0.28072377-4.80233284-2.06706479 0.00745732 0.00076715 0.00014681	1.4532	-1.9341	-0.8895
0.28072377-5.22825611 0.01434626 0.00745732 0.00076222-0.00017054	0.4208	0.2554	-0.0100
2437200.5 0.57838877-4.76366872-2.05777496 0.00742176 0.00116367 0.00031779	1.3958	-1.7082	-0.7972
0.57838877-5.18913215 0.00750251 0.00742176 0.00119404-0.00017145	0.3883	0.2257	-0.0105
2437240.5 0.87412913-4.70921614-2.04163644 0.00736103 0.00155984 0.00048915	1.3041	-1.4169	-0.6589
0.87412913-5.13273770 0.00063582 0.00736103 0.00162549-0.00017171	0.3378	0.1965	-0.0079
2437280.5 1.16693367-4.63864147-2.01864594 0.00727496 0.00195365 0.00066329	1.2170	-1.0742	-0.4903
1.16693367-5.05911796-0.00823284 0.00727496 0.00205506-0.00017154	0.2743	0.1773	-0.0060
2437320.5 1.45578660-4.55296826-1.98882404 0.00716344 0.00234633 0.00083062	1.1002	-0.7096	-0.3315
1.45578660-4.96837699-0.01358024 0.00716344 0.00248127-0.00017072	0.2049	0.1614	-0.0057
2437360.5 1.73986983-4.45145780-1.95221505 0.00702649 0.00273629 0.00099954	0.8256	-0.4053	-0.2068
1.73986983-4.86068153-0.01988290 0.00702649 0.00290256-0.00016931	0.1367	0.1209	-0.0050
2437400.5 2.01756668-4.33462626-1.90888692 0.00686412 0.00311015 0.00116648	0.4960	-0.2613	-0.1512
2.01756668-4.73625648-0.02661715 0.00686412 0.00331749-0.00016730	0.0914	0.0658	-0.0063
2437440.5 2.28846130-4.20274651-1.85893185 0.00667640 0.00348244 0.00133078	0.1739	-0.1411	-0.0097
2.28846130-4.59538895-0.03325900 0.00667640 0.00372441-0.00016469	0.0446	0.0336	-0.0066
2437480.5 2.55134416-4.05615228-1.80244831 0.00646557 0.00384562 0.00149179	-0.2652	-0.0941	-0.0580
2.55134416-4.43843222-0.03978434 0.00646557 0.00412167-0.00016147	0.0122	-0.0217	-0.0030
2437520.5 2.80521742-3.89523929-1.73964158 0.00622600 0.00419811 0.00164082	-.1346	-0.0278	-0.0188
2.80521742-4.26580709-0.04618902 0.00622600 0.00450753-0.00015765	-0.0091	-0.0256	-0.0013
2437560.5 3.04910296-3.72246578-1.67062443 0.00596429 0.00453841 0.00180120	-0.1869	0.0873	0.0367
3.04910296-4.07800281-0.05238926 0.00596429 0.00488037-0.00015325	-0.0369	-0.0183	-0.0006
2437600.5 3.28204700-3.5323+869-1.59561545 0.00567904 0.00486404 0.00194830	-0.2865	0.2247	0.1076
3.28204700-3.87557256-0.05842149 0.00567904 0.00523854-0.00014826	-0.0739	-0.0114	0.0010
2437640.5 3.50312313-3.33146372-1.51483899 0.00537103 0.00517657 0.00208948	-0.4375	0.4526	0.2154
3.50312313-3.65913385-0.06424253 0.00537103 0.00558054-0.00014269	-0.1312	0.0060	0.0019

2437640.524376+0.5 HOLD YOUR HAT, TMAX HAS BEEN REACHED

STPRG2 STEPWISE REGRESSION PROGRAM

N	MTOTAL	SDIN	SDOUT	DIAG
6	110	10.0000000E-10	0.	10.0000000E-09

NO. OF COEFFS IN REGRESSION = 0 SUM OF SQUARED RESIDUALS = 3.91110E-12 S.D. OF DATA = 1.88564E-07

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
				1	1.0084E 01
				2	1.3267E-03
				3	3.8658E-02
				4	3.8575E 00
				5	8.2464E 00
				6	7.3630E 00

INTRODUCING COEFF NO. 1

NO. OF COEFFS IN REGRESSION = 1 SUM OF SQUARED RESIDUALS = 2.02340E-12 S.D. OF DATA = 1.36247E-07

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	1.3048909E-07	1.2940E-08	1.0084E 01		
				2	1.8213E-03
				3	5.2697E-02
				4	7.2172E 00
				5	1.1289E 00
				6	1.4818E 01

INTRODUCING COEFF NO. 6

NO. OF COEFFS IN REGRESSION = 2 SUM OF SQUARED RESIDUALS = 6.67155E-13 S.D. OF DATA = 7.83932E-08

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	1.3247009E-07	7.4654E-09	1.7745E 01		
				2	3.1741E-03
				3	9.1345E-02
				4	5.4889E 01
				5	1.0115E 01
6	7.0142778E-08	4.7336E-09	1.4818E 01		

INTRODUCING COEFF NO. 4

NO. OF COEFFS IN REGRESSION = 3 SUM OF SQUARED RESIDUALS = 2.28798E-14 S.D. OF DATA = 1.46229E-08

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	1.3929662E-07	1.3946E-09	9.9886E 01		
				2	1.7953E-02
				3	4.9076E-01
4	4.8697804E-08	8.8721E-10	5.4889E 01		
				5	2.4441E 01
6	6.9778352E-08	8.8075E-10	7.9226E 01		

INTRODUCING COEFF NO. 5

NO. OF COEFFS IN REGRESSION = 4 SUM OF SQUARED RESIDUALS = 3.44817E-15 S.D. OF DATA = 5.70315E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	1.1322254E-07	1.1975E-09	9.4556E 01		
				2	4.5701E-02
				3	1.2666E 00
6	4.2852175E-08	4.2066E-10	1.0187E 02		
5	-5.6417559E-09	2.4083E-10	-2.4441E 01		
6	7.3399841E-08	3.7412E-10	1.9619E 02		

INTRODUCING COEFF NO. 3

NO. OF COEFFS IN REGRESSION = 5 SUM OF SQUARED RESIDUALS = 3.39628E-15 S.D. OF DATA = 5.68731E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	1.1322253E-07	1.1941E-09	9.4818E 01		
				2	2.9264E-02
3	-9.7446612E-10	7.6937E-10	-1.2666E 00		
4	4.2852166E-08	4.1946E-10	1.0216E 02		
5	-5.6417590E-09	2.3018E-10	-2.4519E 01		
6	7.3399842E-08	3.7306E-10	1.9679E 02		

INTRODUCING COEFF NO. 2

NO. OF COEFFS IN REGRESSION = 6 SUM OF SQUARED RESIDUALS = 3.39625E-15 S.D. OF DATA = 5.71457E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	1.1322253E-07	1.1998E-09	9.4367E 01		
2	-2.2478706E-11	7.6814E-10	-2.9264E-02		
3	-9.7416877E-10	7.7312E-10	-1.2600E 00		
4	4.2852166E-08	4.2147E-10	1.0167E 02		
5	-5.6417598E-09	2.3128E-10	-2.4393E 01		
6	7.3399842E-08	3.7485E-10	1.9581E 02		

LITTLE OMEGA TILDA

8.7613051418873049-07

THIS IS PQR MATRIX

9.7134965371524473-01	2.3666254002684904-03	-2.2759940318647663-02
-2.3659080858034201-01	9.7160825173024323-01	1.4813726738695742-03
2.2464183104942916-02	3.9458618494427403-03	9.9973986140982397-01

ELEMTS

5.2026554561A6953 00	1.4512773813426311-03	4.8910A851532530A5-02	2.2810076266090541-02
1.7446738217092863 00	4.7773841477339703 00	5.2796476910593069 00	

```
 XSOLVE

    1.1322252726615785-07       -2.2478706264648809-11       -3.7416078724103507-10        4.2857166515586684-08
   -5.6617589218332865-09        7.3399842893349804-08
 NEW  PQR

    9.7134944645221899-01        2.7656339128671049-01       -2.2759938044847086-02
   -2.3659165961927878-01        9.7160804447001192-01        1.4813921920840758-03
    2.2464182153366149-02        3.9458615408313955-03        9.9973986151202932-01
 ELLIPTICAL  CORRECTIONS

   -2.9352127005752599-08        0.0000000000000000 00        7.3399842849634980-08       -9.7357166477375836-10
   -1.7904118203495187-09        8.7792117600908001-07       -7.6290852729u6398-07
 NEW    ELEMENTS

    5.2026554212655674 00        1.4502773933158044-03        4.8910758553095936-02        2.2810075292518675-02
    1.7446738195186742 00        4.7773855256551245 00        5.2796469281507972 00
 KEPLERS  3 RD  LAW  MU

    2.9619474115007876-04

                 ****************************************

     PLOD  HAS  EXCEEDED  TOLERANCES  ,IT  WILL  NOW  CORRECT

     EPOCH  VALUES  AND  BEGIN  A  NEW  ITERATION.

     JULIAN  DATE.....  2437680.50

     ELAPSED  TIME  IN  DAYS.....  4400.00

     NUMBER  OF  INTEGRATION  STEPS..  110.

     SIGMA.....  0.18856351E-06

     SIGMA  SQUARE  X  N.....  0.39111818E-11

     X =  3.50312315  Y =  -3.33146372  Z =  -1.51483899


 ****  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....      DELTA  X         DELTA  Y         DELTA  Z
MEAN  DEVIATION  ..............MD=SUM(DELTA)/N    -3.44346163E-06 -0.44687542E-06 -0.18273833E-06
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  0.48353487E-12  0.43107744E-12  0.2733719.7E-13
STANDARD  DEVIATION.............SD=SQRTF(SR-MD**2)  0.53560866E-06  0.4e101916E-06  0.20971079E-06
MAXIMUM  RESIDUAL ..............................  0.25957265E-06  0.1414  48E-06  0.8059498?E-07
MINIMUM  RESIDUAL .............................. -0.13515969E-05 -0.12756477E-05 -0.5405475?E-06

****  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....  RADIUS VECTOR        COSB  DL          DLAT=DB
MEAN  DEVIATION  ..............MD=SUM(DELTA)/N    -7.5R3738?3E-08  0.13654359E-06  0.11533054E-08
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  0.359111?8E-14  0.31956570E-13  0.850839?1E-17
STANDARD  DEVIATION.............SD=SQRTF(SR-MD**2)  0.59640965E-07  0.11537945E-06  0.26792306E-08
MAXIMUM  RESIDUAL ..............................  0.79474?28E-07  0.30?96661E-06  0.60458992E-08
MINIMUM  RESIDUAL .............................. -0.1C061768E-06 -0.47488721E-07 -0.28360631E-08


 ECLIPTIC  PCS-VEL  FROM  TRANSX AND EQUATORIAL  POS-VEL  AFTER  ROTATION  FROM  ECLIPTIC

       3.3493566527842447 00        -3.812+9665500647?8 00        -6.0212645156136956-02
       5.5856649721316345-03         5.3452354907477517 03        -1.4662686851307385-04
       3.3493566527842447 00        -3.7 37659983596274 00        -1.5721612028715143 00
       5.5856549721316345-03         4.9e2248672501948?-03         1.9922660810487130-03

 BEGIN  ITERATION


 EPOCH  VALUES  EQUATORIAL    2433280.50

       3.3493566527842447 00        -3.4737659980596274 00        -1.5721612028715143 00
       5.5856549721316345-03         4.9622486725019481-03         1.9922660810487130-03

 ELEMENTS  CHECK  FROM  SUBR  ELEMTS

       5.2026554212665412 00         1.4502773933158159-03         4.8910758553094361-02        4.0584714672930344-01
       5.6931305210626490-02         1.8660239336151729-01         5.2796469281507972 00

 TRANSPOSE  PQR  MATRIX  CHECK

       9.7134944645220650-01         2.2608774787313957-01         7.3243314634463375-02
      -2.3659163961033357-01         8.9079970485873000-01         3.8794364594155661-01
       2.2464182153366097-02        -3.9415760310471115-01         9.1876627570118497-01

 ECLIPTIC  ELEMENTS

       5.2026554212665412 00         1.4502773933158159-03         4.8910758553094361-02        2.2810075292518647-02
       1.7446738199186760 00         4.7773859256551578 00         5.2796469281507972 00

 ECLIPTIC  PCR  MATRIX

       9.7134944645220650-01         2.3656339128676479-01        -2.2759938?0.6846964-02
      -2.3659165961033357-01         9.7160804446999915-01         1.4813975920852955-03
       2.2464182153366097-02         3.9458616408316?50-03         9.9973946151202870-01
```

EPHEPERIS FORMAT FOR EACH JULIAN DATE IS

JUL-DATE	EQUA. X ECLP. X	EQUA. Y ECLP. Y	EQUA. Z ECLP. Z	EQUA XDOT ECLP XDOT	EQUA YDOT ECLP YDOT	EQUA ZDOT ECLP ZDOT	7PFDX 7PFDP	7PFDY 7PFCOSBDL	7PFDZ 7PFDB
2433280.5	3.34935665-3.47376597-1.57216120		0.00558555	0.00498622^	0.00199226	0.2401	0.3902	0.1514	
	3.34939665-3.81249964-0.06021284		0.00558565	0.0053451	-0.00014661	-0.0306	0.0899	-0.0036	
2433320.5	3.56656304-3.26908711-1.48956344		0.00527699	0.00526898	0.00213154	0.1843	0.5155	0.1895	
	3.56656304-3.59189036-0.06596402		0.00527099	0.00568207	-0.00014087	-0.0511	0.1022	-0.0068	
2433340.5	3.77074730-3.0524-7253-1.40172687		0.00493468	0.00555880	0.00226410	0.1067	0.5309	0.1945	
	3.77074730-3.35817185-0.07147464		0.00493468	0.00600869	-0.00013456	-0.0585	0.0975	-0.0073	
2433400.5	3.96106219-2.82462826-1.36863363		0.00457770	0.00583023	0.00238927	-0.0388	0.4682	0.1650	
	3.96106219-3.11209905-0.07672238		0.00457770	0.00629952	-0.00012773	-0.0667	0.0725	-0.0079	
2433440.5	4.13670254-2.58631727-1.21069123		0.00423115	0.00608190	0.00250645	-0.1395	0.3946	0.1186	
	4.13670254-2.85449437-0.06868588		0.00423115	0.00657703	-0.00012036	-0.0597	0.0377	-0.0034	
2433480.5	4.29691118-2.33635801-1.10823224		0.00380635	0.00631242	0.00261500	-0.1822	0.2149	0.0808	
	4.29691118-2.58624083-0.06634456		0.00380635	0.00683171	-0.00011249	-0.0547	0.0204	-0.0032	
2433520.5	4.44098741-2.08162171-1.00016134		0.00339478	0.00652057	0.00271436	-0.1730	0.1210	0.0394	
	4.44098741-2.30827981-0.09067906		0.00339478	0.00706220	-0.00010415	-0.0423	0.0065	-0.0032	
2433560.5	4.56829089-1.81702571-0.89121273		0.00296798	0.00670522	0.00280401	-0.3522	0.0846	0.0270	
	4.56829089-2.02164332-0.09467115		0.00296798	0.00726728	-0.00009537	-0.0167	0.0119	-0.0021	
2433600.5	4.67824543-1.54453047-0.7774281		0.00252761	0.00686537	0.00288348	0.3417	0.1011	0.0345	
	4.67824543-1.73725080-0.09830384		0.00252761	0.00744583	-0.00008419	0.0005	0.0229	-0.0017	
2433640.5	4.77034098-1.26813509-0.66067580		0.00207533	0.00700007	0.00295232	0.3620	0.1301	0.0520	
	4.77034098-1.42535446-0.10136130		0.00207533	0.00759679	-0.00007662	0.0039	0.0215	-0.0007	
2433680.5	8443138S2-0.91587618-0.54138952		0.00161303	0.00710843	0.00301012	0.0131	0.2539	0.1049	
	.54413850-1.11988793-0.10442916		0.00161303	0.00771920	-0.00006677	-0.0099	0.0544	-0.0012	
2433720 .5	4.89927614-0.69882120-0.42001837		0.00114267	0.00718976	0.00305651	-0.3661	0.3384	0.1229	
	4.89927614-0.80915924-0.10689467		0.00114267	0.00781228	-0.00005651	-0.0248	0.0692	-0.0049	
2433760.5	4.93547189-0.41106297-0.29702434		0.00066629	0.00724352	0.00309122	-0.1539	0.2878	0.0959	
	4.93547189-0.49530476-0.10894688		0.00066629	0.00787541	-0.00004606	-0.0368	0.0575	-0.0062	
2433800.5	4.95252675-0.12671150-0.17287888		0.00018595	0.00726937	0.00311405	-0.1832	0.1409	0.0412	
	4.95252675-0.17953044-0.11057664		0.00018595	0.00790821	-0.00003539	-0.0379	0.0280	-0.0045	
2433840.5	4.95032233 0.17011061-0.06806066		0.00329631	0.00726701	0.00312483	-0.1897	-0.0387	-0.0276	
	4.95032233 0.13694333-0.11177644		0.00329631	0.00791034	-0.00002456	-0.0385	-0.0084	-0.0029	
2433880.5	4.92882407 0.46022717 0.17494589		0.00277838	0.00723612	0.00312345	-0.1897	-0.2079	-0.0949	
	4.92882407 0.45288602-0.11254063		0.00277838	0.00788163	-0.00001362	-0.0424	-0.0430	-0.0020	
2433920.5	4.88808244 0.74863854 0.20165287		0.00125811	0.00717726	0.00310985	-0.1364	-0.1893	-0.0804	
	4.88808244 0.76706254-0.11286539		0.00125811	0.00782204	-0.00000261	-0.0337	-0.0368	-0.0009	
2433960.5	4.82823676 1.03407812 0.32557135		0.00173322	0.00709005	0.00308405	-0.0603	-0.2249	-0.0650	
	4.82823676 1.07824019-0.11274906		0.00173322	0.00773176	0.00000842	-0.0180	-0.0250	-0.0024	
2434000.5	4.74951452 1.31547230 0.44821580		0.00220158	0.00697508	0.00304617	0.0102	-0.0823	-0.0355	
	4.74951452 1.38519961-0.11219198		0.00220158	0.00761121	0.00001942	-0.0031	-0.0180	-0.0001	
2434040.5	4.65222859 1.59172219 0.56910703		0.00266107	0.00683294	0.00299643	-0.0424	-0.0037	-0.0052	
	4.65222859 1.68676174-0.11119650		0.00266107	0.00746101	0.00000033	-0.0084	0.0019	-0.0008	
2434080.5	4.53677285 1.86175482 0.68775529		0.00310975	0.00666435	0.00293506	-0.1979	0.0197	0.0033	
	4.53677285 1.98169552-0.10976674		0.00310975	0.00728191	0.00004112	-0.0456	0.0196	-0.0018	
2434120.5	4.40361905 2.12452573 0.80376102		0.00354564	0.00647000	0.00286236	-0.3523	0.0023	-0.0024	
	4.40361905 2.26891980-0.10790875		0.00354564	0.00707470	0.00005174	-0.0630	0.0327	-0.0020	
2434160.5	4.25331664 2.37902489 0.91661754		0.00396687	0.00625090	0.00277866	-0.4285	-0.0550	-0.0269	
	4.25331664 2.54731023-0.10563045		0.00396687	0.00684039	0.00006213	-0.0804	0.0338	-0.0023	
2434200.5	4.08648992 2.62428194 1.02591318		0.00437155	0.00600810	0.00268439	-0.3949	-0.1804	-0.0834	
	4.08648992 2.81580478-0.10294176		0.00437155	0.00658012	0.00007721	-0.0882	0.0122	-0.0028	
2434240.5	3.90383500 2.85937390 1.13123484		0.00475802	0.00574286	0.00258005	-0.2804	-0.3425	-0.1484	
	3.90383500 3.07331233-0.09985443		0.00475802	0.00629527	0.00008205	-0.0908	-0.0241	-0.0018	
2434280.5	3.70611140 3.08342952 1.23219021		0.00512473	0.00545651	0.00246618	-0.1911	-0.4249	-0.1930	
	3.70611140 3.31911749-0.09638177		0.00512473	0.00598726	0.00009151	-0.0911	-0.0442	-0.0034	
2434320.5	3.49413803 3.29563186 1.32804879		0.00547029	0.00515044	0.00234331	-0.0950	-0.4471	-0.1987	
	3.49413803 3.55208331-0.09253860		0.00547029	0.00565756	0.00010058	-0.0833	-0.0553	-0.0024	
2434360.5	3.26878735 3.49522060 1.41956321		0.00579338	0.00482667	0.00221206	0.0036	-0.3317	-0.1372	
	3.26878735 3.77145497-0.08834112		0.00579338	0.00530775	0.00010922	-0.0539	-0.0476	0.0003	
2434400.5	3.03098372 3.68149498 1.50527020		0.00609275	0.00448500	0.00207305	0.0390	-0.2172	-0.0976	
	3.03098372 3.97645822-0.08380710		0.00609275	0.00493953	0.00011740	-0.0331	-0.0351	-0.0012	
2434440.5	2.78169677 3.85381976 1.58529350		0.00636739	0.00412887	0.00192699	-0.0015	-0.1516	-0.0756	
	2.78169677 4.16639513-0.07895554		0.00636739	0.00455469	0.00012509	-0.0282	-0.0185	-0.0022	
2434480.5	2.52193451 4.01162720 1.65934484		0.00661640	0.00375943	0.00177458	-0.1534	-0.1626	-0.0792	
	2.52193451 4.34063715-0.07380673		0.00661640	0.00415511	0.00013226	-0.0464	0.0083	-0.0023	
2434520.5	2.25273421 4.19441930 1.71818522		0.00683919	0.00337887	0.00161455	-0.2504	-0.2438	-0.1130	
	2.25273421 4.49863231-0.06838171		0.00683919	0.00374264	0.00013889	-0.0700	0.0206	-0.0023	
2434560.5	1.97515614 4.28176439 1.78860368		0.00703520	0.00298735	0.00145360	-0.2278	-0.2770	-0.1107	
	1.97515614 4.63990062-0.06270239		0.00703520	0.00331907	0.00014497	-0.0721	0.0184	0.0008	
2434600.5	1.69028059 4.39329767 1.84341726		0.00720400	0.00258806	0.00128642	-0.3966	-0.2842	-0.1194	
	1.69028059 4.76403463-0.05679138		0.00720400	0.00288623	0.00015047	-0.0639	-0.0024	-0.0000	
2434640.5	1.39920333 4.48872095 1.89147121		0.00734523	0.00218215	0.00111574	0.3776	-0.2596	-0.1378	
	1.39920333 4.87069929-0.05067203		0.00734523	0.00244592	0.00015538	-0.0513	-0.0307	-0.0051	
2434680.5	1.10303193 4.56780553 1.93264022		0.00745870	0.00177141	0.00094230	0.2376	-0.2288	-0.1219	
	1.10303193 4.95963472-0.04436833		0.00745870	0.00200008	0.00015970	-0.0400	-0.0568	-0.0059	
2434720.5	0.80281658 4.63039166 1.96682863		0.00754444	0.00135751	0.00076683	0.2881	-0.1507	-0.0947	
	0.80281658 5.03805532-0.03790446		0.00754444	0.00155936	0.00016339	-0.0251	-0.0513	-0.0055	
2434760.5	0.5[illegible]84492 4.67636671 1.99396960		0.00760256	0.00094212	0.00059005	0.3000	-0.0404	-0.0379	
	0.49[illegible]84492 5.08365297-0.03130490		0.00760256	0.00109910	0.00016648	-0.0044	-0.0594	-0.0037	
2434800.5	[illegible]03571 4.70576173 2.01402408		0.00763335	0.00052676	0.00041261	0.2449	0.1292	0.0380	
	.19503571 5.11858201-0.02459396		0.00763335	0.00064744	0.00016896	0.0279	-0.0468	-0.0031	
2434840.5	-0.11046228 4.71854872 2.02697909		0.00763707	0.00011297	0.00025519	0.1361	0.1306	0.0287	
	-0.11046228 5.13546783-0.01779625		0.00763707	0.00019722	0.00017082	0.0250	-0.0270	-0.0049	
2434880.5	-0.41557477 4.71486077 2.03284833		0.00761415	0.00029774	0.00005843	0.3491	0.0211	-0.0172	
	-0.41557477 5.13440126-0.01093627		0.00761415	0.00024991	0.00017207	0.0017	-0.0097	-0.0047	
2434920.5	-0.71924576 4.69478995 2.03167108		0.00756510	0.00070392	0.00011702	-0.3223	-0.1131	-0.0595	
	-0.71924576 5.11853746-0.00403844		0.00756510	0.00069236	0.00017271	-0.0238	0.0077	-0.0019	
2434960.5	-1.02044377 4.65860611 2.02351215		0.00749062	0.00110418	0.00029056	0.3066	-0.2440	-0.1266	
	-1.02044377 5.07907483 0.00287308		0.00749062	0.00112862	0.00017276	-0.0525	0.0092	-0.0035	
2435000.5	-1.31816581 4.60655040 2.00845909		0.00739142	0.00149731	0.00046163	0.1093	-0.2459	-0.1315	
	-1.31816581 5.02534765 0.00977485		0.00739142	0.00155736	0.00017223	-0.0571	-0.0068	-0.0043	
2435040.5	-1.61143772 4.53893262 1.98862110		0.00726824	0.00188210	0.00062972	0.2468	-0.1775	-0.0958	
	-1.61143772 4.95462370 0.01664369		0.00726824	0.00197726	0.00017112	-0.0513	-0.0331	-0.0032	
2435080.5	-1.89931545 4.45810809 1.95812744		0.00712182	0.00225745	0.00079433	0.3747	-0.0947	-0.0774	
	-1.89931543 4.86750033 0.02348689		0.00712182	0.00278711	0.00016944	-0.0471	-0.0586	-0.0062	
2435120.5	-2.18388517 4.35847795 1.92312773		0.00693300	0.00262219	0.00095493	0.3948	-0.0157	-0.0291	
	-2.18388517 4.76385513 0.03019214		0.00693300	0.00327563	0.00016722	-0.0359	-0.0644	-0.0037	
2435160.5	-2.45526931 4.24648768 1.88179186		0.00676271	0.00297529	0.00111107	0.2808	0.1066	0.0236	
	-2.45526931 4.64661428 0.03682784		0.00676271	0.00317171	0.00016447	-0.0070	-0.0568	-0.0039	
2435200.5	-2.72162905 4.12062317 1.83430758		0.00655196	0.00331575	0.00126228	0.1577	0.1067	0.0176	
	-2.72162905 4.51024848 0.04336310		0.00655196	0.00354423	0.00016121	0.0015	-0.0359	-0.0050	
2435240.5	-2.97916791 3.98140609 1.78037931		0.00632182	0.00364280	0.00140821	0.3658	0.0658	0.0073	
	-2.97916791 4.36126745 0.04971796		0.00632182	0.00390234	0.00015745	0.0028	-0.0170	-0.0037	
2435280.5	-3.22712913 3.82938859 1.72172564		0.00607325	0.00395565	0.00154850	0.3202	-0.0738	-0.0482	
	-3.22712913 4.19826484 0.05593305		0.00607325	0.00424918	0.00015322	-0.0154	0.0074	-0.0026	
2435320.5	-3.44479607 3.66515306 1.65707868		0.00580727	0.00425354	0.00166282	0.3442	-0.2196	-0.1127	
	-3.44479607 4.02186928 0.06196977		0.00581727	0.00457196	0.00014853	-0.0389	0.0225	-0.0035	
2435360.5	-3.69149190 3.48831006 1.58718371		0.00552487	0.00453590	0.00181084	0.3291	-0.2936	-0.1322	
	-3.69149190 3.83273253 0.06781017		0.00552487	0.00488190	0.00014341	-0.0424	0.0332	-0.0033	
2435400.5	-3.90658271 3.30249795 1.51229912		0.00522721	0.00480195	0.00193226	0.3578	-0.2150	-0.1260	
	-3.90658271 3.63154903 0.07343750		0.00522721	0.00517429	0.00013787	-0.0396	0.0266	-0.0051	
2435440.5	-4.10947949 3.10537738 1.43269394		0.00491535	0.00505123	0.00204683	0.1050	-0.0965	-0.0631	
	-4.10947949 3.41902995 0.07883513		0.00491535	0.00544858	0.00013195	-0.0288	0.0038	-0.0032	
2435480.5	-4.29963660 2.89862836 1.34866491		0.00459040	0.00528328	0.00215432	0.1140	0.0375	0.0156	
	-4.29963660 3.19591045 0.08398861		0.00459040	0.00570425	0.00012566	-0.0126	-0.0188	0.0001	
2435520.5	-4.47655088 2.68294948 1.26044678		0.00425337	0.00549770	0.00225458	0.3322	0.1639	0.0523	
	-4.47655088 2.96294427 0.08888350		0.00425337	0.00594086	0.00011902	0.0125	-0.0299	-0.0034	
2435560.5	-4.63976002 2.45905373 1.16838272		0.00390533	0.00569403	0.00234728	-0.1377	0.1989	0.0653	
	-4.63976002 2.72090426 0.09350626		0.00390533	0.00615786	0.00011206	0.0416	-0.0205	-0.0043	
2435600.5	-4.78884548 2.22767228 1.07276390		0.00354737	0.00587193	0.00243238	-0.3395	0.1704	0.0513	
	-4.78884548 2.47058144 0.09784436		0.00354737	0.00635491	0.00010479	0.0703	-0.0006	-0.0051	
2435640.5	-4.92343330 1.98954928 0.97389843		0.00318065	0.00603107	0.00250959	-0.3584	0.0325	-0.0125	
	-4.92343330 2.21278188 0.10188618		0.00318065	0.00653165	0.00009725	0.0623	0.0230	-0.0057	
2435680.5	-5.04319596 1.74543835 0.87210171		0.00280629	0.00617131	0.00257891	-0.2965	-0.0782	-0.0433	
	-5.04319596 1.94832250 0.10562125		0.00280629	0.00668789	0.00008946	0.0452	0.0331	-0.0029	
2435720.5	-5.14784837 1.49609861 0.76769240		0.00242531	0.00629248	0.00264021	-0.2039	-0.1648	-0.0912	
	-5.14784837 1.67802650 0.10903989		0.00242531	0.00682345	0.00008143	0.0290	0.0446	-0.0038	
2435760.5	-5.23714640 1.24229491 0.66099269		0.00203873	0.00639449	0.00269341	-0.1795	-0.1420	-0.0866	

-5.23714650 1.49272382 0.11213334-0.00203873-0.00693820 0.00007320		0.0062	0.0331	-0.0044
2435830.5-5.31088555 0.98479731 0.55232777-0.00164753-0.00647715-0.00273845		-0.0426	-0.0432	-0.0295
-5.31088555 1.12325028 0.11489358-0.00164753-0.00703195 0.00006678		0.0057	0.0109	-0.0019
2435840.5-5.36890203 0.72438252 0.44202686-0.00125279-0.00654034-0.00277521		-0.0152	0.0708	0.0239
-5.36890203 0.84044947 0.11731360-0.00125279-0.00710455 0.00005619		0.0049	-0.0131	-0.0012
2435880.5-5.41107595 0.46182974 0.33942140-0.00035557-0.00658403 0.00280367		-0.0298	0.2095	0.0836
-5.41107595 0.55516817 0.11938742-0.00035557-0.00715596 0.00004747		0.0096	-0.0407	-0.0014
2435920.5-5.43732983 0.19791903 0.21784420-0.00045696-0.00660826-0.00282380		-0.1349	0.2558	0.1052
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2435960.5-5.44762737-0.06657273 0.10462774-0.00005791-0.00661309-0.00283563		-0.2535	0.2370	0.0822
-5.44762737-0.01944686 0.12247740-0.00005791-0.00719534 0.00002971		0.0463	-0.0	-0.0041
2436000.5-5.44197059-0.33087054-0.00889552 0.00034058-0.00654857-0.00283914		-0.3162	0.1844	0.0527
-4.44197059-0.30709223 0.12348608 0.00034058-0.00718342 0.00002071		0.0561	-0.0344	-0.0043
2436040.5-5.42940122-0.59423178-0.12239321 0.00073755-0.00656477-0.00283435		-0.3106	0.0821	0.0153
-5.42940122-0.59384062 0.12413365 0.00073755-0.00715051 0.00001165		0.0549	-0.0210	-0.0017
2436080.5-5.38350103-0.85579708-0.23553332 0.00113194-0.00651186-0.00282127		-0.1759	-0.0372	-0.0007
-5.38350103-0.87885415 0.12441858 0.00113194-0.00709869 0.00000258		0.0332	0.0039	-0.0049
2436120.5-5.32989383-1.11469338-0.34798534 0.00152273-0.00643987-0.00279997		-0.0447	-0.0422	-0.0423
-5.32989383-1.16135118 0.12434047 0.00152273-0.00702223-0.00000648		0.0101	0.0082	-0.0043
2436160.5-5.26124209-1.37073718-0.45942207 0.00193901-0.00634921-0.00277051		0.0205	-0.0276	-0.0127
-5.26124209-1.44030734 0.12389975 0.00193901-0.00692734-0.00001553		-0.0021	0.0064	-0.0001
2436200.5-5.17724556-1.62258424-0.56951923 0.00228983-0.00624008-0.00273300		0.0477	0.0518	0.0266
-5.17724556-1.71521972 0.12339775 0.00228983-0.00681229-0.00002455		-0.0114	-0.0074	0.0010
2436240.5-5.07813931-1.86969995-0.67795591 0.00266434-0.00611265-0.00268746		-0.0475	0.1657	0.0848
-5.07813931-1.98507737 0.12193647 0.00266434-0.00667728-0.00003350		-0.0042	-0.0349	0.0023
2436280.5-4.96419615-2.11135542-0.78441323 0.00303151-0.00592716-0.00263405		-0.1716	0.1762	0.0734
-4.96419615-2.24912874 0.12041891 0.00303151-0.00652253-0.00004236		0.0142	-0.0449	-0.0008
2436320.5-4.83572906-2.34683537-0.88857615 0.00339337-0.00580791-0.00257279		-0.2798	0.1019	0.0271
-4.83572906-2.50662121 0.11856905 0.00339337-0.00634838-0.00005111		0.0367	-0.0406	-0.0037
2436360.5-4.69309062-2.57543638-0.99013435 0.00373992-0.00562328-0.00250385		-0.3782	-0.0556	-0.0197
-4.69309062-2.75675634 0.11633185 0.00373992-0.00615925-0.00005972		0.0654	-0.0259	-0.0007
2436400.5-4.53667176-2.79647312-1.08878422 0.00407926-0.00542576-0.00242740		-0.3639	-0.1861	-0.0753
-4.53667176-2.99879453 0.11377317 0.00407926-0.00594361-0.00006818		0.0762	-0.0061	-0.0007
2436440.5-4.36689740-3.00927699-1.18422863 0.00440753-0.00521171-0.00234360		-0.2315	-0.2526	-0.1185
-4.36689740-3.23206420 0.11087459 0.00440753-0.00571389-0.00007646		0.0647	0.0159	-0.0028
2436480.5-4.18422800-3.21319610-1.27617677 0.00472387-0.00498159-0.00225262		-0.1395	-0.2297	-0.1350
-4.18422800-3.45567161 0.10765857 0.00472387-0.00546657-0.00008455		0.0452	0.0230	-0.0018
2436520.5-3.98915899-3.40799566-1.36434419 0.00502735-0.00473581-0.00215460		0.0373	-0.2077	-0.1022
-3.98915899-3.66910106 0.10411843 0.00502735-0.00520208-0.00009241		0.0238	0.0360	-0.0025
2436560.5-3.78222400-3.59185994-1.44845365 0.00531702-0.00447493-0.00204976		0.0942	-0.1052	-0.0484
-3.78222400- .87161750 0.10026859 0.00531702-0.00492102-0.00010003		0.0031	0.0274	-0.0006
2436600.5-3.56399214- .76539668-1.52823706 0.00559204-0.00419953-0.00193833		0.0454	-0.0207	0.0157
-3.56399214- .86257081 0.09611934 0.00559204-0.00462402-0.00010738		-0.0037	0.0079	0.0043
2436640.5-3.33506715-3.92763716-1.60343561 0.00585155-0.00391023-0.00182056		-0.0223	0.1048	0.0481
-3.33506715-4.24133629 0.09168185 0.00585155-0.00431176-0.00011444		0.0142	-0.0165	0.0007
2436680.5-3.09608489-4.07803780-1.67380065 0.00609477-0.00360763-0.00169669		-0.1532	0.1371	0.0526
-3.09608489-4.40731633 0.08696795 0.00609477-0.00398485-0.00012119		-0.0060	-0.0389	-0.0011
2436720.5-2.84771454-4.21607870-1.73909281 0.00632080-0.00329236-0.00156494		-7.2304	0.0402	0.0139
-2.84771454-4.55993873 0.08199038 0.00632080-0.00364400-0.00012762		0.0160	-0.0405	-0.0008
2436760.5-2.59066042-4.34126765-1.79908377 0.00652682-0.00296515-0.00143167		-0.2364	-0.0799	-0.0489
-2.59066042-4.69866097 0.07676281 0.00652682-0.00328998-0.00013369		0.0364	-0.0332	-0.0030
2436800.5-2.32566106-4.45314251-1.85355708 0.00671793-0.00262681-0.00129114		-0.2053	-0.1699	-0.0852
-2.32566106-4.82297301 0.07129987 0.00671793-0.00292365-0.00013939		0.0485	-0.0191	-0.0026
2436840.5-2.05348730-4.55127597-1.90231058 0.00688743-0.00227822-0.00114574		-0.0949	-0.1200	-0.0601
-2.05348730-4.93240237 0.06561708 0.00688743-0.00254600-0.00014468		0.0300	-0.0068	-0.0018
2436880.5-1.77493753-4.63527854-1.94515637 0.00703661-0.00192025-0.00099581		0.0602	0.0124	-0.0062
-1.77493753-5.02651417 0.05973060 0.00703661-0.00215793-0.00014956		-0.0054	0.0101	-0.0019
2436920.5-1.49383742-4.70478356-1.98192094 0.00716484-0.00155380-0.00084174		0.1059	0.1495	0.0598
-1.49383742-5.10491139 0.05365738 0.00716484-0.00176402-0.00015402		-0.0346	0.0106	-0.0005
2436960.5-1.20203903-4.75947762-2.01246515 0.00727140-0.00117971-0.00068396		-0.1182	0.2322	0.0651
-1.20203903-5.16723472 0.04741506 0.00727140-0.00135440-0.00015801		-0.0511	0.0110	-0.0005
2437000.5-0.90942371-4.79907280-2.03618515 0.00735558-0.00079903-0.0005226		0.0120	0.3119	0.1150
-0.90942371-5.21316564 0.04102231 0.00735558-0.00094100-0.00016154		-0.0622	-0.0085	-0.0030
2437040.5-0.61389899-4.82332695-2.05421478 0.00741676-0.00041284-0.00035842		-0.1434	0.2719	0.1020
-0.61389899-5.24243176 0.03449850 0.00741676-0.00052137-0.00016456		-0.0514	-0.0334	-0.0024
2437080.5-0.31639632-4.83204257-2.06522650 0.00745440-0.00002231-0.00019179		-0.1751	0.2283	0.0862
-0.31639632-5.25486920 0.02788174 0.00745440-0.00009678-0.00016708		-0.0442	-0.0360	-0.0020
2437120.5-0.01786608-4.82506943-2.06951269 0.00746807 0.00037140-0.00002322		-0.1606	0.1370	0.0461
-0.01786608-5.25012511 0.02113859 0.00746807 0.00033153-0.00016908		-0.0273	-0.0307	-0.0022
2437160.5 0.28072392-4.80233284-2.06706488 0.00745732 0.00076715 0.00014681		-0.1957	-0.0000	-0.0130
0.28072392-5.22825629 0.01434425 0.00745732 0.00076222-0.00017054		0.0000	-0.0183	-0.0023
2437200.5 0.57838891-4.76368684-2.05777504 0.00742176 0.00116367 0.00031779		0.0121	-0.0172	-0.0300
0.57838891-5.18913233 0.00750253 0.00742176 0.00119404-0.00017145		0.0047	0.0018	-0.0044
2437240.5 0.87412925-4.70921636-2.04163650 0.00736103 0.00155964 0.00048915		0.0881	0.0538	0.0042
0.87412925-5.13273782 0.00065582 0.00736103 0.00162549-0.00017178		-0.0068	0.0183	-0.0034
2437280.5 1.16693377-4.63894159-2.01866600 0.00727496 0.00195365 0.00066029		0.1647	0.1864	0.0738
1.16693377-5.05911773-0.00623214 0.00727496 0.00205506-0.00017154		-0.0296	0.0404	-0.0010
2437320.5 1.45578669-4.55296838-1.98882408 0.00716344 0.00234433 0.00043066		0.2215	0.3431	0.1377
1.45578669-4.96837711-0.01308024 0.00716344 0.00248127-0.00001707		-0.0565	0.0611	-0.0021
2437360.5 1.73966990-4.45145792-1.95221409 0.00702649 0.00273028 0.00099930		0.1148	0.4520	0.1713
1.73966990-4.86088185-0.01988290 0.00702649 0.00290256-0.00016931		-0.0805	0.0524	-0.0047
2437400.5 2.01756674-4.33462632-1.90888695 0.00686412 0.00311015 0.00116648		-0.0485	0.4077	0.1389
2.01756674-4.73625660-0.02661715 0.00686412 0.00331749-0.00016730		-0.0804	0.0240	-0.0077
2437440.5 2.28846133-4.20274657-1.85891187 0.00667640 0.00348244 0.00133078		-0.2059	0.3450	0.1049
2.28846133-4.5953891-0.03329900 0.00667640 0.00372441-0.00016469		-0.0803	-0.0048	-0.0085
2437480.5 2.55134419-4.05615234-1.80246833 0.00646357 0.00384562 0.00149179		-0.2819	0.2129	0.0696
2.55134419-4.43843228-0.03978434 0.00646357 0.00412167-0.00016147		-0.0647	-0.0263	-0.0058
2437520.5 2.80521744-3.89523932-1.73936158 0.00622600 0.00419811 0.00164882		-0.1896	0.1024	0.0390
2.80521744-4.26580715-0.04616902 0.00622600 0.00450753-0.00015765		-0.0370	-0.0201	-0.0049
2437560.5 3.04910296-3.72046578-1.67062443 0.00596429 0.00453841 0.00180121		-0.0808	0.0414	-0.0080
3.04910296-4.07800281-0.05238926 0.00596429 0.00488037-0.00015325		-0.0149	-0.0086	-0.0048
2437600.5 3.28204697-3.53234866-1.59561543 0.00567904 0.00486504 0.00194830		-0.3190	0.0019	-0.0198
3.28204697-3.87557256-0.05842148 0.00567904 0.00523856-0.00014826		-0.0014	-0.0036	-0.0037
2437640.5 3.50312310-3.33146366-1.51483898 0.00537103 0.00517657 0.00208948		-0.0068	0.0510	0.0049
3.50312310-3.65913382-0.06424253 0.00537103 0.00558054-0.00014269		-0.0078	0.0057	-0.0032

2437640.52437640.5 HOLD YOUR HAT, TMAX HAS BEEN REACHED

STPRG2 STEPWISE REGRESSION PROGRAM

N	MTOTAL	SDIN	SDOUT	DIAG
6	110	10.0000000E-18	0.	10.0000000-09

NO. OF COEFFS IN REGRESSION = 0 SUM OF SQUARED RESIDUALS = 3.47916E-15 S.D. OF DATA = 5.62395E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
				1	3.0201E-01
				2	2.4268E-03
				3	2.0372E-03
				4	1.1233E 00
				5	3.4961E-01
				6	3.6005E-02

INTRODUCING COEFF NO. 4

NO. OF COEFFS IN REGRESSION = 1 SUM OF SQUARED RESIDUALS = 3.43935E-15 S.D. OF DATA = 5.61727E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
				1	4.0402E-01
				2	2.4480E-03
				3	2.0542E-03
4	-3.8129113E-10	3.3944E-10	-1.1233E 00		
				5	1.0336E-01
				6	4.6230E-02

INTRODUCING COEFF NO. 1

NO. OF COEFFS IN REGRESSION = 2 SUM OF SQUARED RESIDUALS = 3.43416E-15 S.D. OF DATA = 5.63895E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	-2.1724221E-10	5.3769E-10	-4.0403E-01		
				2	2.4364E-03
				3	2.0456E-03
4	-3.9363839E-10	3.4212E-10	-1.1506E 00		
				5	5.1501E-01
				6	3.9154E-02

INTRODUCING COEFF NO. 5

NO. OF COEFFS IN REGRESSION = 3 SUM OF SQUARED RESIDUALS = 3.42567E-15 S.D. OF DATA = 5.65823E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	-7.1962281E-10	1.1147E-09	-6.4555E-01		
				2	2.4365E-03
				3	2.0439E-03
4	-5.0531716 -10	4.0604E-10	-1.2445E 00		
5	-1.0829340 -10	2.1028E-10	-5.1501E-01		
				6	2.6368E-01

INTRODUCING COEFF NO. 6

NO. OF COEFFS IN REGRESSION = 4 SUM OF SQUARED RESIDUALS = 3.42342E-15 S.D. OF DATA = 5.68306E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	-8.2838248E-10	1.1932E-09	-6.9426E-01		
				2	2.4270E-03
				3	2.0355E-03
4	-5.3083455E-10	4.1914E-10	-1.2665E 00		
5	-1.3231349E-10	2.3000E-10	-5.7526E-01		
6	9.8292943E-11	3.7277E-10	2.6368E-01		

INTRODUCING COEFF NO. 2

NO. OF COEFFS IN REGRESSION = 5 SUM OF SQUARED RESIDUALS = 3.42342E-15 S.D. OF DATA = 5.70999E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	-8.2838250E-10	1.1989E-09	-6.9098E-01		
2	1.8625869E-12	7.6746E-10	2.4273E-03		
				3	2.0577E-03
4	-5.3083457E-10	4.2114E-10	-1.2605E 00		
5	-1.3231350E-10	2.3110E-10	-5.7214E-01		
6	9.8292947E-11	3.7455E-10	2.6243E-01		

INTRODUCING COEFF NO. 3

NO. OF COEFFS IN REGRESSION = 6 SUM OF SQUARED RESIDUALS = 3.42342E-15 S.D. OF DATA = 5.73738E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	-8.2838259E-10	1.2046E-09	-6.8768E-01		
2	1.8834441E-12	7.7127E-10	2.4422E-03		
3	-1.5972474E-12	7.7621E-10	-2.0577E-03		
4	-5.3083458E-10	4.2315E-10	-1.2545E 00		
5	-1.3231351E-10	2.3221E-10	-5.6981E-01		
6	9.8292950E-11	3.7634E-10	2.6118E-01		

LITTLE OMEGA TILTA

-1.0853147831657632-08

THIS IS PQR MATRIX

9.7134944445221899-01	2.3656339128671049-01	-2.2759938046847086-02
-2.3659165961027878-01	9.7160804447001192-01	1.3813925920840758-03
2.2466182153361449-02	3.9458616408313955-03	9.9973986151202932-01

ELEMTS

5.2026554212665674 00	1.4532773933158044-03	4.8910758553095936-02	2.2810079292518675-02
1.7446738199186742 00	4.7773850256551345 00	5.2796469281503540 00	

```
 XSOLVE

    -8.2838256023376065-10          1.8834441584080476-12          -1.5972474087214103-12          -5.3086345867v574171-10
    -1.3231350955377556-10          9.8292795107379036D-11
 NEW  PQR

     9.7134944902001408-01          2.3656338074173157-01          -2.2759938061327992-02
    -2.3659164906805782-01          9.7160804703747183-01           1.4813923469505486-03
     2.2464182152260270-02          3.9458616386235652-03           9.9973986151206284-01
 ELLIPTICAL  CORRECTIONS

    -6.8838159778675600-10          0.0000000000000000 00           9.82929510/3793363-11          -1.4715445727409813-12
    -8.6951908195007163-11         -1.0766198863462624-08           1.0024742671871039-06
 NEW    ELEMENTS

     5.2026554205781648 00          1.4502773936036420-03           4.8910758651387408-02          2.2810075391047126-02
     1.7446738198317220 00           .7773850148889077 00           5.2796469381755964 00
 KEPLERS  3 RD  LAW  MU

     2.9619474115007876-04

                  ********************************** **********

      PLOD  HAS  EXCEEDED  TOLERANCES  ,IT  WILL  NOW  CORRECT

      EPOCH  VALUES  AND  BEGIN  A  NEW  ITERATION.

      JULIAN  DATE.....  2437088.50

      ELAPSED  TIME  IN  DAYS.....  4400.00

      NUMBER  OF  INTEGRATION  STEPS..  110.

      SIGMA.....  0.56239460E-08

      SIGMA  SQUARE  X  N.....  0.3479167E-14

      X  =  3.53312310  Y  =  -3.33146366  Z  =  -1.51483898


 ****  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....  DELTA  X  DELTA  Y  DELTA  Z
MEAN  DEVIATION .....MD=SUM(DELTA)/N  -0.52230789E-08  0.20318047E-08 -0.51625236E-09
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  0.33405570E-15  0.43.86093E-15  0.74907642E-16
STANDARD  DEVIATION.....SD=SQRT(SR-MD**2)  0.17571498E-07  0.20675C9E-07  0.86395095E-08
MAXIMUM  RESIDUAL .....  0.39475589E-07  0.53091193E-07  0.19449382E-07
MINIMUM  RESIDUAL ..... -0.42852726E-07 -0.44712155E-07 -0.19873080E-07

****  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....  RADIUS VECTOR  COSB  DL  DLAT=DB
MEAN  DEVIATION .....MD=SUM(DELTA)/N  -0.16776.57E-08 -0.20966224E-09 -0.28694171E-09
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  0.14864396E-16  0.12637914E-16  0.12645912E-18
STANDARD  DEVIATION.....SD=SQRT(SR-MD**2)  0.40662495E-08  0.35487954E-08  0.21055603E-09
MAXIMUM  RESIDUAL .....  0.76166800E-08  0.13215840E-07  0.4258922eE-09
MINIMUM  RESIDUAL ..... -0.91072404E-08 -0.66443450E-08 -0.85314030E-09

 ECLIPTIC  POS-VEL  FROM  TRANSX AND EQUATORIAL  POS-VEL  AFTER  ROTATION  FROM  ECLIPTIC

     3.3493566468757567 00         -3.8124946543238418 00         -6.0212645073052764-02
     5.5856549787778927-03          5.3452354899176120-03         -1.4660688864115090-04
     3.3493566468757567 00         -3.4737C59974664148 00         -1.572.612025236840 00
     5.5856549787778927-03          4.9622486717913.64-03          1.9922660806C09134-03

 BEGIN  ITERATION


 EPOCH  VALUES  EQUATORIAL    2433280.50

     3.3493566468757C567 00         -3.4737659974664.48 00         -1.5721612025236840 00
     5.5856549787778927-03          4.9622486717913.64-03          1.9922660806a0c9134-03

 ELEMENTS  CHECK  FROM  SUBR  ELEMTS

     5.2026554205781617 00          1.4502773936036521-03          4.8910758651387408-02          4.0384714673145061-01
     5.6931305207536455-02          1.8660278251121689-01          5.2796469381755511 00

 TRANSPOSE  PQR  MATRIX  CHECK

     9.7134944902000436-01          2.2608773820693699-01          7.3243310425524427-02
    -2.3659164906810010-01          8.9079573731174918-01          3.8794366673820692-01
     2.2464182152260190-02         -3.9415786314.74999-01          9.1876827570338681-01

 ECLIPTIC  ELEMENTS

     5.2026554205781617 00          1.4502773936036521-03          4.8910758651387408-02          2.2810075 91047083-02
     1.7446738198317209 00          4.7773850148889512 00          5.2796469381755511 00

 ECLIPTIC  PQR  MATRIX

     9.7134944902000436-01          2.3656338074177351-01          -2.2759938061327867-02
    -2.3659164906810010-01          9.7160804703746173-01           1.4813923469515489-03
     2.3464182152260190-02          3.9458616386235544-03           9.9973986151206179-01
```

EPHEMERIS FORMAT FOR EACH JULIAN DATE IS

JUL-DATE	EQUA. X / ECLP. X	EQUA. Y / ECLP. Y	EQUA. Z / ECLP. Z	EQUA XDOT / ECLP XDOT	EQUA YDOT / ECLP YDOT	EQUA ZDOT / ECLP ZDOT	TPFDX / TPFDP	TPFDY / TPFCOSBDL	TPFDZ / TPFDN
2433280.5	3.34935662-3.47376597-1.57216120	0.00550565	0.00476224	0.00199226	0.2803	0.3842	0.1479
	3.34935662-3.81249464-0.86021264	0.00558565	0.00534523	-0.00014661	-0.0244	0.0950	-0.0037
2433424.5	3.54656304-3.26908711-1.48966344	0.00527099	0.00526898	0.00021315	0.2220	0.5097	0.1862
	3.54656304-3.59189034-1.66596432	0.00527099	0.00568207	-0.00014087	-0.0450	0.1067	-0.0069
2433568.5	3.77574436-3.65247253-1.40172687	0.00493468	0.00555880	0.00226410	0.1418	0.5251	0.1912
	3.77574436-3.35817185-0.97147464	0.00493468	0.00600069	-0.00013456	-0.0524	0.1812	-0.0376
2433640.5	3.96126214-2.82466324-1.3008.3363	0.00457770	0.00583013	0.00238927	-0.0061	0.4423	0.1617
	3.96126214-3.11229905-0.87872238	0.00457770	0.00629952	-0.00012773	-0.0607	0.0755	-0.0080
2433440.5	4.13670254-2.58631727-1.21069122	0.00420115	0.00608190	0.00250645	-0.1090	0.2985	0.1153
	4.13670254-2.85449430-0.68186588	0.00420115	0.00657703	-0.00012036	-0.0539	0.0400	-0.0034
2433480.5	4.29691118-2.33835811-1.10023224	0.00380635	0.00631262	0.00261560	-0.1538	0.2080	0.0772
	4.29691118-2.58624020-0.86634456	0.00380635	0.00683171	-0.00011249	-0.0490	0.0220	-0.0032
2433520.5	4.44298741-2.08162171-1.00161344	0.00339478	0.00652057	0.00271436	-0.1465	0.1135	0.0355
	4.44298741-2.32827981-0.69667906	0.00339478	0.00708220	-0.00010415	-0.0348	0.0075	-0.0032
2433560.5	4.56829089-1.81762571-0.89121273	0.00298798	0.00670522	0.00280401	-0.2274	0.0764	0.0228
	4.56829089-2.02160332-0.69467115	0.00298798	0.00726728	-0.00009537	-0.0114	0.0123	-0.0021
2433600.5	4.67824543-1.54653045-0.77742817	0.00252781	0.00686537	0.00288348	-0.3648	0.0921	0.0301
	4.67824543-1.72725082-0.59838384	0.00252781	0.00744583	-0.00008619	-0.0055	0.0226	-0.0017
2433640.5	4.77336498-1.26813549-0.66867588	0.00207533	0.00700007	0.00295232	0.3838	0.1202	0.0472
	4.77336498-1.42630446-0.10156139	0.00207533	0.00759679	-0.00007662	0.0387	0.0296	-0.0007
2433680.5	4.84413850-1.98587618-0.54138952	0.00161303	0.00710845	0.00301012	0.3337	0.2431	0.0997
	4.84413850-1.11988793-0.10442916	0.00161303	0.00771920	-0.00006671	-0.0053	0.0530	-0.0012
2433720.5	4.89927614-1.69982120-0.42091437	0.00114267	0.00718976	0.00305651	-0.2465	0.3267	0.1174
	4.89927614-1.80915924-0.10689467	0.00114267	0.00781228	-0.00005651	-0.0205	0.0673	-0.0049
2433760.5	4.93547189-1.41106296-0.29772434	0.00066629	0.00724352	0.00309122	-0.1352	0.2751	0.0900
	4.93547189-1.49533078-0.10894688	0.00066629	0.00787541	-0.00004684	-0.0328	0.0551	-0.0061
2433800.5	4.95252675-1.12071150-0.17287888	0.00018585	0.00728937	0.00311605	-0.1652	0.1274	0.0450
	4.95252675-1.17953044-0.11057664	0.00018585	0.00790821	-0.00003539	-0.0342	0.0252	-0.0035
2433840.5	4.9533227 1.17211061-0.04804044	0.00029631	0.00726761	0.00312483	-0.1722	-0.0531	-0.0342
	4.95032227 1.13694333-0.11177644	0.00029631	0.00791034	-0.00002456	-0.0350	-0.0116	-0.0029
2433880.5	4.92882407 1.04377218 0.07896589	0.00077838	0.00723632	0.00312345	-0.1727	-0.2250	-0.1038
	4.92882407 0.95498602-0.11254063	0.00077838	0.00788163	-0.00001362	-0.0393	-0.0466	-0.0021
2433920.5	4.88838244 0.74863854 0.20165287	0.00125811	0.00717726	0.00310985	-0.1197	-0.2051	-0.0877
	4.88838244 0.76706254-0.11286539	0.00125811	0.00782204	-0.00000261	-0.0309	-0.0408	-0.0005
2433960.5	4.82823676 1.03467814 0.32557133	0.00173322	0.00709305	0.00308405	-0.0438	-0.1413	-0.0725
	4.82823676 1.07824622-0.11274906	0.00173322	0.00773176	0.00000842	-0.0156	-0.0293	-0.0024
2434000.5	4.74951452 1.31547238 0.44821586	0.00222155	0.00697508	0.00304617	0.0263	-0.0992	-0.0496
	4.74951452 1.38519961-0.11219198	0.00222155	0.00761121	0.00001942	-0.0010	-0.0225	-0.0001
2434040.5	4.65222859 1.59172219 0.56013704	0.00266121	0.00683264	0.00299643	-0.0362	-0.0210	-0.0131
	4.65222859 1.68676419-0.11116695	0.00266107	0.00746101	0.00003033	-0.0066	-0.0028	-0.0009
2434080.5	4.53677285 1.86175482 0.68777529	0.00311075	0.00666433	0.00293506	-0.1817	0.0821	-0.0048
	4.53677285 1.98169552-0.10976674	0.00311075	0.00728191	0.00004112	-0.0336	0.0147	-0.0018
2434120.5	4.40361905 2.12452573 0.80376162	0.00354564	0.00647060	0.00286236	-0.3358	-0.0155	-0.0105
	4.40361905 2.26891980-0.10790875	0.00354564	0.00707470	0.00005177	-0.0619	-0.0277	-0.0021
2434160.5	4.25331664 2.37902492 0.91661754	0.00396687	0.00625090	0.00277866	-0.4124	-0.0729	-0.0351
	4.25331664 2.54731023-0.10563045	0.00396687	0.00684039	0.00006213	-0.0797	0.0287	-0.0023
2434200.5	4.08648992 2.62428197 1.02591318	0.00437155	0.00600810	0.00268439	-0.3788	-0.1985	-0.0916
	4.08648992 2.81586481-0.10294176	0.00437155	0.00658012	0.00007225	-0.0878	0.0071	-0.0029
2434240.5	3.90383556 2.89937396 1.13123484	0.00475852	0.00574286	0.00258005	-0.2645	-0.3604	-0.1584
	3.90383556 3.10792233-0.09954643	0.00475852	0.00629527	0.00008205	-0.0907	-0.0292	-0.0019
2434280.5	3.70611140 3.28342952 1.23219621	0.00512473	0.00545651	0.00246616	-0.1754	-0.4423	-0.2011
	3.70611140 3.31911749-0.09638177	0.00512473	0.00598724	0.00009151	-0.0913	-0.0492	-0.0035
2434320.5	3.49413803 3.29563189 1.32868879	0.00547029	0.00511344	0.00234331	-0.3795	-0.4647	-0.2068
	3.49413803 3.55208331-0.09253666	0.00547029	0.00565756	0.00010058	-0.0839	-0.0502	-0.0025
2434360.5	3.26678735 3.49122050 1.41954321	0.00579338	0.00482607	0.00221206	0.2188	-0.3490	-0.1451
	3.26678735 3.77145407-0.08834112	0.00579338	0.00530775	0.00010922	-0.0948	-0.0524	0.0002
2434400.5	3.03098372 3.68149498 1.55527026	0.00609275	0.00448500	0.00207305	0.3548	-0.2343	-0.1094
	3.03098372 3.97663822-0.08380716	0.00609275	0.00493953	0.00011740	-0.0343	-0.0397	-0.0013
2434440.5	2.78169677 3.85381976 1.58529356	0.00636739	0.00412887	0.00197899	0.4127	-0.1685	-0.0833
	2.78169677 4.16639513-0.07495554	0.00636739	0.00455469	0.00012509	-0.0297	-0.0229	-0.0023
2434480.5	2.52193491 4.01262720 1.65935484	0.00661440	0.00375943	0.00177458	-0.1398	-0.1791	-0.0848
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	2.25273421 4.49883231-0.06836171	0.00681919	0.00374284	0.00013889	-0.0720	0.0167	-0.0074
2434560.5	1.97515614 4.28176439 1.78860368	0.00703520	0.00298735	0.00145360	-0.2158	-0.2930	-0.1180
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	1.39920333 4.87649929-0.05537628	0.00736523	0.00244592	0.00015938	-0.0540	-0.0335	-0.0052
2434680.5	1.10303193 4.56786593 1.93264922	0.00745870	0.00177141	0.00094232	0.2467	-0.2445	-0.1370
	1.10303193 4.95943672-0.04434833	0.00745870	0.00230008	0.00015975	-0.0430	-0.0893	-0.0060
2434720.5	0.82387858 4.63233713 1.96478842	0.00751551	0.00136683	0.00076603	0.2960	-0.1664	-0.1018
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2434760.5	0.49984492 4.67638871 1.99396960	0.00756256	0.00094212	0.00059055	0.3047	-0.0563	-0.0450
	0.49984492 5.08362597-0.03139490	0.00756256	0.00109910	0.00016648	-0.0076	-0.0611	-0.0037
2434800.5	0.19953571 4.70576173 2.01602408	0.00761335	0.00052676	0.00041261	0.2504	0.1130	0.0308
	0.19953571 5.11858201-0.02469396	0.00761335	0.00064744	0.00016896	0.0245	-0.0480	-0.0031
2434840.5-0.11346228	4.71854872 2.02697909	0.00763707	0.00011297	0.00023519	0.1403	0.1141	0.0214
	-0.11346228 5.13546783-0.01779625	0.00763707	0.00019722	0.00017082	0.0215	-0.0278	-0.0049
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243 +20.5-0.71924576	4.69828995 2.00316709	0.00757549	0.00047032	0.00015702	-0.0206	-0.1307	-0.0072
	-0.71924576 5.11553748-0.00463846	0.00757549	0.00060236	0.00017271	-0.0276	0.0079	-0.0019
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2435000.5-1.31818581	4.60655904 2.00845904	0.00739142	0.00149731	0.00046163	0.7085	-0.2651	-0.1398
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2435200.5-2.72162905	4.12062317 1.83630758	0.00655196	0.00331575	0.00126228	0.1519	0.0817	0.0070
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2435440.5-4.10947949	3.10537741 1.43269396	0.00445135	0.00505121	0.00204683	0.3973	-0.307	-0.1776
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2435480.5-4.29963660	2.89862886 1.34886491	0.00395060	0.00528328	0.00213432	0.1065	0.0018	0.0004
	-4.29963660 3.19591048 0.08398861	0.00395060	0.00570425	0.00012566	-0.0157	-0.0121	0.0002
2435520.5-4.47655088	2.68294448 1.26344479	0.00343537	0.00549770	0.00225455	0.3250	0.1266	0.0385
	-4.47655088 2.98294427 0.08888350	0.00343537	0.00594084	0.00011902	0.0095	-0.0229	-0.0033
2435560.5-4.63978202	2.45905373 1.16430272	0.00289533	0.00567643	0.00234726	-0.1445	0.1601	0.0488
	-4.63978202 2.72050428 0.09350628	0.00289533	0.00615786	0.00011206	0.0187	-0.0131	-0.0042
2435600.5-4.78884548	2.22747228 1.07276390	0.00234737	0.00587193	0.00243235	-0.3416	0.1301	0.0342
	-4.78884548 2.47058144 0.09784436	0.00234737	0.00635491	0.00010479	0.0676	0.0071	-0.0050
2435640.5-4.92343330	1.98056928 0.97389863	0.00181065	0.00603107	0.00250959	-0.1637	-0.0092	-0.0302
	-4.92343330 2.21278185 0.10148618	0.00181065	0.00657169	0.00009725	0.0598	0.0311	-0.0056
2435680.5-5.04319596	1.74543817 0.87210.71	0.00128629	0.00617131	0.00257891	-0.3010	-0.1212	-0.0616
	-5.04319596 1.94832252 0.10562129	0.00128629	0.00668789	0.00008946	0.0428	0.0435	-0.0024
2435720.5-5.14784037	1.49639861 0.76769240	0.00242591	0.00629248	0.00264021	-0.2074	-0.2089	-0.1100
	-5.14784037 1.67802651 0.10993989	0.00242591	0.00682345	0.00008143	0.0229	0.0532	-0.0037
2435760.5-5.23714650	1.24229492 0.66099269	0.00203873	0.00639449	0.00269341	-0.3879	-0.1873	-0.1060

-5.21716650	1.40272382	0.11213334	-0.00203873	-0.00699820	0.00007320	0.0043	0.0420	-0.0043
2435840.5 -5.31088555	0.98670731	0.55232777	-0.00144753	-0.00667715	-0.00273845	-0.2497	-0.0895	-0.0499
-5.31088555	1.12325028	0.11489358	-0.00164753	-0.00703195	0.00030478	0.0040	0.0200	-0.0018
2435840.5 -5.36890203	0.72438252	0.44202687	-0.00125279	-0.00654034	-0.00277521	-0.3151	0.0236	0.0037
-5.36890203	0.84044967	0.11731360	-0.00125279	-0.00714455	0.00005619	0.0334	-0.0038	-0.0012
2435880.5 -5.41107595	0.46182979	0.33042140	-0.00085557	-0.00658403	-0.00280367	-0.3283	0.1616	0.0638
-5.41107595	0.55516817	0.11938742	-0.00085557	-0.00715596	0.00004747	0.0084	-0.0312	-0.0014
2435920.5 -5.43732983	0.19791904	0.21784420	-0.00045696	-0.00660826	-0.00282380	-0.1320	0.2072	0.0844
-5.43732983	0.28825435	0.12111005	-0.00045696	-0.00718620	0.00001864	0.0262	-0.0398	-0.0015
2435960.5 -5.44762737	-0.06657272	0.10462775	-0.00005791	-0.00661309	-0.00283563	-0.2491	0.1830	0.0611
-5.44762737	-0.01944646	0.12247740	-0.00005791	-0.00719534	0.00002971	0.0455	-0.0354	-0.0041
2436000.5 -5.44197659	-0.33067054	-0.00889552	0.00034058	-0.00659857	-0.00283914	-0.3184	0.1132	0.0314
-5.44197659	-0.27709222	0.12348608	0.00034058	-0.00718362	0.00002071	0.0356	-0.0245	-0.0042
2436040.5 -5.42240128	-0.59420177	-0.12239221	0.00073755	-0.00656477	-0.00283435	-0.3031	0.0325	-0.0041
-5.42240128	-0.59384062	0.12413365	0.00073755	-0.00715051	0.00001165	0.0546	-0.0111	-0.0046
2436080.5 -5.38300103	-0.85479767	-0.13553332	0.00113194	-0.00651180	-0.00282127	-0.1671	-0.0868	-0.0621
-5.38300103	-0.87885614	0.12461858	0.00113194	-0.00709669	0.00000758	0.0332	0.0139	-0.0049
2436120.5 -5.32989383	-1.11489335	-0.14798534	0.00152273	-0.00643987	-0.0027 97	-0.0344	-0.0917	-0.0617
-5.32989383	-1.16130118	0.12434047	0.00152273	-0.00702229	-0.00003648	0.0103	-0.0183	-0.0043
2436160.5 -5.26124209	-1.37073718	-0.15942207	0.00191901	-0.00634921	-0.00277051	0.0322	-0.0968	-0.0348
-5.26124209	-1.44036054	0.12389975	0.00191901	-0.00692734	-0.00001553	-0.0016	0.0144	-0.0001
2436200.5 -5.17724556	-1.62258422	-0.16951923	0.00228983	-0.00624008	-0.00273300	0.0607	0.0030	0.0054
-5.17724556	-1.71521972	0.12330775	0.00228983	-0.00681229	-0.00002455	-0.0108	0.0027	0.0009
2436240.5 -5.07813936	-1.84969955	-0.17795591	0.00266436	-0.00611265	-0.00268749	-0.0332	0.1174	-0.0630
-5.07813936	-1.98507735	0.12193647	0.00266436	-0.00667728	-0.00005350	-0.0232	-0.0249	0.0022
2436280.5 -4.96419615	-2.11135542	-0.18441323	0.00303151	-0.00596714	-0.00263405	-0.1561	0.1285	0.0527
-4.96419615	-2.24913874	0.12041891	0.00303151	-0.00652253	-0.00004236	0.0156	-0.0350	-0.0049
2436320.5 -4.83572936	-2.34683537	-0.18857615	0.00339037	-0.00580391	-0.00257279	-0.2631	0.0549	0.0063
-4.83572936	-2.50462121	0.11854905	0.00339037	-0.00634438	-0.00005111	0.0383	-0.0309	-0.0037
2436360.5 -4.69109062	-2.57543638	-0.19013435	0.00373992	-0.00562 78	-0.00250385	-0.3606	-0.1017	-0.0398
-4.69309062	-2.75675634	0.11633185	0.00373992	-0.00615525	-0.00005972	0.0673	-0.0163	-0.0007
2436400.5 -4.53667176	-2.79647312	-0.18878422	0.00407926	-0.00542576	-0.00242740	-0.3455	-0.2313	-0.7930
-4.53667176	-2.99879453	0.11377117	0.00407926	-0.00594361	-0.00006818	0.0763	0.0039	-0 007
2436440.5 -4.36685746	-3.02927699	-0.18422863	0.00440753	-0.00521171	-0.00234346	-0.2123	-0.2967	-0 377
-4.36685746	-3.23200626	0.11047959	0.00440753	-0.00571389	-0. 0007646	0.0672	0.0251	- 029
2436480.5 -4.18422800	-3.21319616	-0.17617677	0.00472387	-0.00 "159	-0.00225242	-0.3698	-0.2728	- 238
-4.18422800	-3.45557161	0.10765857	0.00472387	-0.0054u657	-0.00008455	0.0479	0.0320	-0.0019
2436520.5 -3.98915899	-3.40759566	-0.16634418	0.00502755	-0.00473581	-0.00215460	0.0573	-0.2496	-0.1265
-3.98915899	-3.66910106	0.10411841	0.00502735	-0.00520708	-0.00009241	0.0268	0.0448	-0.0026
2436560.5 -3.78222400	-3.59185994	-0.14845365	0.00531702	-0.00447493	-0.00204976	0.1145	-0.1460	-0.0664
-3.78222400	-3.87161750	0.10026859	0.00531702	-0.00492103	-0.00010003	0.0064	0.0358	-0.0006
2436600.5 -3.56395214	-3.76539868	-0.12823706	0.00559294	-0.00421953	-0.00193833	0.0658	-0.0602	-0.0016
-3.56399214	-4.06257041	0.09611934	0.00559294	-0.00462402	-0.00010138	-0.0002	0.0160	0.0042
2436640.5 -3.32506715	-3.92763713	-1.60343561	0.00585155	-0.0391023	-0.00182056	-0.3021	0.0664	0.0313
-3.33506715	-4.24133629	0.09148169	0.00585155	-0.00431176	-0.00011444	-0.0104	-0.0087	0.0008
2436680.5 -3.09608489	-4.07833780	-1.67380063	0.00609477	-0.00360763	-0.00169669	-0.1332	0.0999	0.0363
-3.09608489	-4.40731633	0.08696795	0.00609477	-0.00398485	-0.00012119	-0.0019	-0.0316	-0.0012
2436720.5 -2.84771454	-4.21607670	-1.73909281	0.00632080	-0.00329236	-0.00156696	-0.2110	0.0041	-0.0019
-2.84771454	-4.55993873	0.08199038	0.00632080	-0.00364400	-0.00012762	0.0203	-0.0336	-0.0009
2436760.5 -2.59366042	-4.34126765	-1.79408377	0.00652882	-0.00296515	-0.00143167	-0.2175	-0.1149	-0.0642
-2.59366042	-4.69866097	0.07676281	0.00652882	-0.00328998	-0.00013369	0.0409	-0.0237	-0.0030
2436800.5 -2.32566106	-4.45314252	-1.85355708	0.00671793	-0.00262661	-0.00129114	-0.1873	-0.2039	-0.1001
-2.32566106	-4.82297301	0.07129987	0.00671793	-0.00292365	-0.00013939	0.0533	-0.0131	-0.0027
2436840.5 -2.05346733	-4.55127597	-1.90231057	0.00688743	-0.00227822	-0.00114574	-0.3779	-0.1530	-0.0745
-2.05346733	-4.93260237	0.0656.708	0.00688743	-0.00256600	-0.00001468	0.0950	-0.0012	-0.0018
2436880.5 -1.77493753	-4.63527554	-1.94515634	0.00702681	-0.00192325	-0.00095581	0.0762	-0.0198	-0.0002
-1.77493753	-5.02651417	0.05973066	0.00702681	-0.00215793	-0.00010456	-0.0001	0.0151	-0.0020
2436920.5 -1.49083742	-4.70478356	-1.98192094	0.00716484	-0.00155380	-0.00084174	0.1206	0.1179	0.0461
-1.49083742	-5.10491139	0.05365738	0.00716484	-0.00176042	-0.00015402	-0.0292	0.0151	-0.0006
2436960.5 -1.20203905	-4.75947762	-2.01246515	0.00727140	-0.0.117971	-0.00068366	0.1315	0.2012	0.0816
-1.20203905	-5.16723472	0.04741506	0.00727140	-0.0135440	-0.00015801	-0.3455	0.0149	-0.0006
2437000.5 -0.90942371	-4.79907280	-2.03658515	0.00735558	-0.00079903	-0.00052261	0.5238	0.2813	0.1017
-0.90942371	-5.21316564	0.04102231	0.00735558	-0.00094100	-0.00016154	-0.3564	-0.0053	-0.0031
2437040.5 -0.61389899	-4.82332695	-2.05421478	0.00741678	-0.00041284	-0.00035842	-0.1331	0.2419	0.0869
-0.61389899	-5.24263176	0.03449950	0.00741678	-0.00052137	-0.00016456	-0.0456	-0.0307	-0.0025
2437080.5 -0.31639632	-4.85224257	-2.06522647	0.00745449	-0.00002231	-0.00019179	-0.1665	0.1979	0.0731
-0.31639632	-5.25682920	0.02786374	0.00745449	-0.00029678	-0.00016708	-0.0381	-0.0340	-0.0020
2437120.5 -0.01786608	-4.82526943	-2.06953269	0.00746807	0.00037140	-0.00002322	-0.1537	0.1064	0.0329
-0.01786608	-5.25312511	0.02113859	0.00746807	0.00033150	-0.00016908	-0.0210	-0.0293	-0.0022
2437160.5 0.28072392	-4.80230284	-2.06726485	0.00745732	0.00076715	0.00014681	-0.3904	-0.0310	-0.0262
0.28072392	-5.22825629	0.01434425	0.00745732	0.00078222	-0.00017054	0.0065	-0.0176	-0.0013
2437200.5 0.57838691	-4.76368684	-2.05777505	0.00742176	0.00116367	0.00031779	0.0157	-0.0437	-0.0435
0.57838691	-5.18913233	0.00750250	0.00742176	0.00119404	-0.00017145	0.0113	0.0018	-0.0043
2437240.5 0.87412925	-4.70921636	-2.04163650	0.00736103	0.00155964	0.00048915	0.0899	0.0215	-0.0095
0.87412925	-5.13273782	0.00066582	0.00736103	0.00162549	-0.00017174	-0.0001	0.0175	-0.0033
2437280.5 1.16693377	-4.63894159	-2.01864600	0.00727498	0.00195365	0.00066029	0.1699	0.1491	0.0596
1.16693377	-5.03911773	0.00623284	0.00727498	0.00205504	-0.00017156	-0.0228	0.0388	-0.0049
2437320.5 1.45557869	-4.55296838	-1.98882408	0.00716344	0.00234433	0.00083062	0.2202	0.3086	0.1230
1.45578869	-4.96837711	-0.01308024	0.00716344	0.00248127	-0.00017072	-0.3496	0.0586	-0.0020
2437360.5 1.73966990	-4.85145792	-1.96221509	0.00702759	0.00273029	0.00099954	0.1120	0.4161	0.1561
1.73966990	-4.86068165	-3.01988290	0.00702759	0.00290256	0.00016931	-0.0736	0.0494	-0.0046
2437400.5 2.01756674	-4.83462632	-1.90888695	0.00686412	0.00311015	0.00116648	-0.3526	0.9703	0.1230
2.01756674	-4.73625660	-0.02661715	0.00686412	0.00331749	-0.00016730	-0.3714	0.0202	-0.0071
2437440.5 2.28866133	-4.70274657	-1.85893187	0.00667640	0.00348244	0.00133078	-0.2141	0.3057	0.0882
2.28866133	-4.59538901	-0.03325900	0.00667640	0.00372441	-0.00016469	-0.3733	-0.0094	-0.0084
2437480.5 2.55134419	-4.05615234	-1.80246831	0.00646357	0.00384562	0.00149179	-0.2881	0.1717	0.0451
2.55134419	-4.43643228	-0.03978459	0.00646357	0.00412167	-0.00016147	-0.3517	-0.0317	-0.0057
2437520.5 2.80521744	-3.80523932	-1.73984158	0.00622690	0.00419811	0.00164882	-0.1965	0.0590	0.0006
2.80521744	-4.26880715	-0.04616902	0.00622690	0.00450753	-0.00015765	-0.3500	-0.0263	-0.0048
2437560.5 3.04910296	-3.72046575	-1.67062443	0.00596429	0.00453841	0.00183121	-0.3882	-0.0042	-0.0273
3.04910296	-4.07800281	-0.05238726	0.00596429	0.00488037	-0.00015925	-0.3080	-0.0156	-0.0047
2437600.5 3.28204697	-3.53234866	-1.59561543	0.00567904	0.00488504	0.00194830	-0.3267	-0.0460	-0.0401
3.28204697	-3.87557253	-0.05842148	0.00567904	0.00523856	-0.00014876	0.0054	-0.0114	-0.0036
2437640.5 3.50312310	-3.33146366	-1.51483896	0.00537103	0.00517657	0.00208944	-0.2145	0.0007	-0.0164
3.50312310	-3.65913379	-0.06424253	0.00537103	0.00558054	-0.00014289	-0.3011	-0.0029	-0.0030

2437640.52437640.5 HOLD YOUR HAT, TMAX HAS BEEN REACHED

STPRGZ STEPWISE REGRESSION PROGRAM

N	MTOTAL	SDIN	SDOUT	DIAG
6	110	10.000000E-18	0.	10.000000E-09

NO. OF COEFFS IN REGRESSION = 0 SUM OF SQUARED RESIDUALS = 3.42266E-15 S.D. OF DATA = 5.57809E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
				1	3.4295E-03
				2	3.0908E-05
				3	2.3296E-05
				4	2.2668E-03
				5	5.7461E-03
				6	6.9655E-03

INTRODUCING COEFF NO. 6

NO. OF COEFFS IN REGRESSION = 1 SUM OF SQUARED RESIDUALS = 3.42265E-15 S.D. OF DATA = 5.60361E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
				1	3.2900E-03
				2	3.0758E-05
				3	2.3184E-05
				4	2.3196E-03
				5	5.4257E-03
6	-2.3554972E-12	3.3745E-10	-6.9855E-03		

INTRODUCING COEFF NO. 5

NO. OF COEFFS IN REGRESSION = 2 SUM OF SQUARED RESIDUALS = 3.42265E-15 S.D. OF DATA = 5.62950E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
				1	8.1873E-04
				2	3.0606E-05
				3	2.3064E-05
				4	1.3348E-03
5	-4.4582886E-13	1.0074E-10	-4.4257E-03		
6	-2.0451130E-12	3.4596E-10	-5.9115E-03		

INTRODUCING COEFF NO. 4

NO. OF COEFFS IN REGRESSION = 3 SUM OF SQUARED RESIDUALS = 3.42265E-15 S.D. OF DATA = 5.65574E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
				1	1.1601E-04
				2	3.0486E-05
				3	2.2974E-05
4	4.6868263E-13	3.5112E-10	1.3348E-03		
5	-4.1402C11E-13	1.0397E-10	-3.9825E-03		
6	-2.0711521E-12	3.4812E-10	-5.9496E-03		

INTRODUCING COEFF NO. 1

NO. OF COEFFS IN REGRESSION = 4 SUM OF SQUARED RESIDUALS = 3.42265E-15 S.D. OF DATA = 5.68296E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	-1.3041012E-13	1.1931E-09	-1.1001E-04		
				2	3.2340E-05
				3	2.2865E-05
4	4.4243404E-13	4.1910E-10	1.0557E-03		
5	-4.3779355E-13	2.2998E-10	-1.9036E-03		
6	-2.0562039E-12	3.7273E-10	-5.5166E-03		

INTRODUCING COEFF NO. 2

NO. OF COEFFS IN REGRESSION = 5 SUM OF SQUARED RESIDUALS = 3.42265E-15 S.D. OF DATA = 5.70935E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	-1.3840964E-13	1.1987E-09	-1.1546E-04		
2	-2.3281983E-14	7.6737E-10	-3.0346E-05		
				3	2.3134E-05
4	4.4243431E-13	4.2109E-10	1.0507E-03		
5	-4.3779344E-13	2.3107E-10	-1.8946E-03		
6	-2.0562039E-12	3.7450E-10	-5.4909E-03		

INTRODUCING COEFF NO. 3

NO. OF COEFFS IN REGRESSION = 6 SUM OF SQUARED RESIDUALS = 3.42265E-15 S.D. OF DATA = 5.73673E-09

COEFFS IN REGRESSION				COEFFS NOT IN REGRESSION	
INDEX	COEFF	S.D.	COEFF/S.D.	INDEX	PREDICTED (COEFF/S.D.)
1	-1.3840944E-13	1.2045E-09	-1.1491E-04		
2	-2.3516648E-14	7.7112E-10	-3.0497E-05		
3	1.7970700E-14	7.7812E-10	2.3134E-05		
4	4.4243448E-13	4.2311E-10	1.0457E-03		
5	-4.3779340E-13	2.3218E-10	-1.8856E-03		
6	-2.0562039E-12	3.7630E-10	-5.4643E-03		

LITTLE OMEGA TILTA

9.0460307027829443-12

THIS IS POR MATRIX

9.7134944902001408-01	2.3656338074173157-01	-2.2759938061327992-02
-2.3659164906805782-01	9.7160804703747183-01	1.4813923466950488-03
2.2464182152260270-02	3.9458616386235652-03	9.9973986191206284-01

ELEMTS

5.2026556205781848 00	1.4502773936038420-03	4.8910758651388886-02	2.2610077191647126-02
1.7446738198317220 00	4.7773853148889477 00	5.2796469381755964 00	

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XSOLVE

   -1.3842944161233965-13        -2.3516448605321395-14        1.7970699583615964-14        4.4243448219177045-13
   -4.3779340792407577-13        -2.0542039640948258-12
NEW  PCR

    9.7134944901787390-01         2.3656338075051911-01        -2.2759938061332557-02
   -2.3659164907884363-01         9.7160804703533210-01         1.4813923471328943-03
    2.2644182152272161-02         3.9458616386506590-03         9.9973986151206251-01
ELLIPTICAL  CORRECTIONS

   -2.2776882468295887-12         0.0000000000000000 00        -2.0562039640948258-12        1.6465341560856806-14
    1.0800635526748514-12         7.9689671501026926-12        -9.1841501782951445-12
NEW    ELEMENTS

    5.2026554205759966 00         1.4502773936045944-03         4.8910758643332677-02        2.2810075291063532-02
    1.7446738198320020 00         4.7773850148960733 00         5.2796446938[illegible]7 00
KEPLERS  3 RD  LAW  MU

    2.9619474115007876-04

                  ••••••••••••••••••••••••••••••••••••••••

     PLCD  HAS  EXCEEDED  TOLERANCES  .IT  .ILL  NOW  CORRECT

     EPOCH  VALUES  AND  BEGIN  A  NEW  ITERATION.

     JULIAN  DATE.....  2437680.50

     ELAPSED  TIME  IN  DAYS.....  4409.00

     NUMBER  OF  INTEGRATION  STEPS..  110.

     SIGMA.....  ^.557838668-08

     SIGMA  SQUARE  X  M.....  0 942226555E-14

     X =  3.5C312310  Y =  -3.33146266  Z =  -1.51483896


**** STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....     DELTA  X        DELTA  Y        DELTA  Z
MEAN  DEVIATION  .....MD=SUM(DELTA1/N   -C.42892414E-08 -0.83791432E-09 -0.17694701E-08
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  0.32222179E-15  0.42781132E-15  0.77699653E-16
STANDARD  DEVIATION.....SD=SQRT(FISR-MD**2)  0.17430554E-07  0.20666320E-07  0.8815330J3E-08
MAXIMUM  RESIDUAL  .....  0.39070722E-07  0.52513056E-07  0.19119292E-07
MINIMUM  RESIDUAL  .....  -0.41242868E-07 -0.46449782E-07 -0.20677716E-07

**** STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....  RADIUS VECTOR      COSB  DL       DLAT/DE
MEAN  DEVIATION  .....MD=SUM(DELTA1/A    -0.15345264E-08  0.13673989E-11 -0.28716111E-09
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  0.18107385E-16  0.12882458E-16  0.12553734E-18
STANDARD  DEVIATION.....SD=SQRT(FISR-MD**2)  0.39689183E-08  0.35892136E-08  0.20747493E-09
MAXIMUM  RESIDUAL  .....  0.78335823E-08  0.10651725E-07  0.41672321E-09
MINIMUM  RESIDUAL  .....  -0.91334759E-08 -0.63867634E-08 -0.84156846E-09

ECLIPTIC  POS-VEL  FROM  TRANSX AND EQUATORIAL  POS-VEL  AFTER  ROTATION  FROM  ECLIPTIC

    3.3493566487720410 00        -3.8124946543170761 00        -6.0712645073352694-02
    5.5856549787635310-03         5.3452354999199460-03        -1.4460688686410[illegible]874-04
    3.3493566487720410 00        -3.4737659974600885 00        -1.5721612025212675 00
    5.5856549787635310-03         4.9622[illegible]6717934020-03        1.9922660806019335-03

BEGIN  ITERATION


EPOCH  VALUES  EQUATORIAL    2433280.50

    3.3493566487720410 00        -3.4737659974600885 00        -1.5721612025212675 00
    5.5856549787635310-03         4.9622486717934020-03        1.9922660806019335-03

ELEMENTS  CHECK  FROM  SUBR  ELEMTS

    5.2026554205758799 00         1.4502773936046060-03         4.8910758649330706-02        4.0584714673142414-01
    5.6931365205569967-02         1.8660238252023592-01         5.2796469381663611 00

TRANSPOSE  PQR  MATRIX  CHECK

    9.7134944901786313-01         2.2638773821260530-01         7.3243310429016715-02
   -2.3659164907689118-01         8.9679972733971270-01         3.8794364673752266-01
    2.2644132192272152-02        -3.9615760313672529-01         9.1876827570034775-01

ECLIPTIC  ELEMENTS

    5.2026554205758799 00         1.4502773936046060-03         4.8910758649330706-02        2.2810075291063906-02
    1.7446738198328013 00         4.7773851148969212 00         5.2796446938663611 00

ECLIPTIC  PQR  MATRIX

    9.7134944901786313-01         2.3656338075056636-01        -2.2759938061332453-02
   -2.3659164907689118-01         9.7160804703532111-01         1.4813923471340140-03
    2.2644182152272152-02         3.9458616386509273-03         9.9973986151206207-01
```

EPHEMERIS FORMAT FOR EACH JULIAN DATE IS

JUL-DATE	EQUA. X ECLP. X	EQUA. Y ECLP. Y	EQUA. Z ECLP. Z	EQUA XDOT ECLP XDOT	EQUA YDOT ECLP YDOT	EQUA ZDOT ECLP ZDOT	TPFDX TPFDP	TPFDY TPFCOSBDL	TPFDZ TPFDB
2433280.5	3.34925662	-3.47376597	-1.57216120	0.00559565	0.00496224	0.00199226	0.2802	0.3842	0.1479
	3.34935662	-3.41249464	-0.06021264	0.00558565	0.00534523	-0.00014661	-0.0244	0.0950	-0.0037
2433320.5	3.56656304	-3.26908711	-1.48946344	0.00527099	0.00528898	0.00213154	0.2216	0.5097	0.1861
	3.56656304	-3.59189036	-0.06596402	0.00527099	0.00568287	-0.00014087	-0.0459	0.1065	-0.0069
2433360.5	3.77074730	-3.05247253	-1.40172687	0.00493468	0.00555880	0.00226410	0.1417	0.5251	0.1912
	3.77074730	-3.55817185	-0.07147464	0.00493468	0.00600069	-0.00013456	-0.0524	0.1011	-0.0074
2433400.5	3.96106216	-2.82462826	-1.30863363	0.00457770	0.00583023	0.00238927	-0.2562	0.4622	0.1617
	3.96106216	-3.11209905	-0.07672238	0.00457770	0.00629952	-0.00012773	-0.0607	0.0755	-0.0080
2433440.5	4.13670254	-2.58631727	-1.21049123	0.00420115	0.00608180	0.00250645	-0.1091	0.2982	0.1153
	4.13670254	-2.85449630	-0.08168588	0.00420115	0.00657703	-0.00012036	-0.0539	0.0440	-0.0034
2433480.5	4.29691118	-2.33835801	-1.10923224	0.00383635	0.00631242	0.00261506	-0.1539	0.2080	0.0772
	4.29691118	-2.58624080	-0.08634456	0.00383635	0.00683171	-0.00011249	-0.0490	0.0220	-0.0032
2433520.5	4.44098741	-2.08162171	-1.00161344	0.00339478	0.00652057	0.00271436	-0.1466	0.1134	0.0355
	4.44098741	-2.30827981	-0.09067906	0.00339478	0.00706220	-0.00010415	-0.0368	0.0074	-0.0032
2433560.5	4.56829089	-1.81702571	-0.89121273	0.00296798	0.00670522	0.00280401	-0.2275	0.0763	0.0228
	4.56829089	-2.02160332	-0.09467115	0.00296798	0.00726728	-0.00009537	-0.0314	0.0122	-0.0021
2433600.5	4.67824543	-1.54553045	-0.77742817	0.00252761	0.00686537	0.00288348	0.3647	0.0920	0.0301
	4.67824543	-1.72725080	-0.09830384	0.00252761	0.00744583	-0.00008619	0.0055	0.0226	-0.0017
2433640.5	4.77034098	-1.26813509	-0.66067580	0.00207533	0.00700007	0.00295232	0.3837	0.1201	0.0472
	4.77034098	-1.42630448	-0.10156130	0.00207533	0.00759679	-0.00007662	0.0087	0.0296	-0.0007
2433680.5	4.84413858	-0.98587618	-0.54138952	0.00161303	0.00710863	0.00301012	0.3336	0.2430	0.0947
	4.84413858	-1.11198793	-0.10442916	0.00161303	0.00771920	-0.00006671	-0.0053	0.0530	-0.0012
2433720.5	4.89927614	-0.69982120	-0.42001837	0.00114267	0.00718976	0.00305651	-0.0456	0.3266	0.1173
	4.89927614	-0.80915924	-0.10684467	0.00114267	0.00781228	-0.00005651	-0.0205	0.0673	-0.0049
2433760.5	4.93547189	-0.41106296	-0.29702434	0.00066629	0.00724352	0.00309122	-0.1353	0.2751	0.0900
	4.93547189	-0.49930476	-0.10894688	0.00066629	0.00787541	-0.00004506	-0.0328	0.0551	-0.0061
2433800.5	4.95252675	-0.12071150	-0.17287888	0.00018595	0.00726937	0.00311405	-0.1653	0.1273	0.0350
	4.95252675	-0.17953044	-0.11057664	0.00018595	0.00790821	-0.00003539	-0.0342	0.0251	-0.0045
2433840.5	4.95032227	0.17011061	-0.34806066	0.00029631	0.00726701	0.00312483	-0.1723	-0.0931	-0.0342
	4.95032227	0.13694333	-0.11177644	0.00029631	0.00791034	-0.00002456	-0.0351	-0.0116	-0.0029
2433880.5	4.92862407	0.46027218	0.07694589	0.00077838	0.00723632	0.00312345	-0.1728	-0.2250	-0.1038
	4.92862407	0.45288042	0.11254063	0.00077838	0.00788153	-0.00001362	-0.0393	-0.0466	-0.0021
2433920.5	4.88808244	0.74863856	0.20165287	0.00125811	0.00717726	0.00310985	-0.1198	-0.2051	-0.0877
	4.88808244	0.76706256	0.11286539	0.00125811	0.00782204	-0.00000261	-0.0309	-0.0408	-0.0005
2433960.5	4.82823676	1.03407814	0.32557133	0.00173322	0.00709005	0.00308405	-0.0439	-0.1413	-0.0725
	4.82823676	1.07824020	0.11274906	0.00173322	0.00773176	0.00000842	-0.0156	-0.0293	-0.0024
2434000.5	4.74951452	1.31547238	0.44821580	0.00220158	0.00697508	0.00304617	0.0264	-0.0992	-0.0436
	4.74951452	1.38519961	0.11219198	0.00220158	0.00761121	0.00001942	-0.0010	-0.0225	-0.0001
2434040.5	4.65222859	1.59172219	0.56910703	0.00266107	0.00683294	0.00299643	-0.0263	-0.0210	-0.0131
	4.65222859	1.68674274	0.11119656	0.00266107	0.00744101	0.00003033	-0.0067	-0.0025	-0.0009
2434080.5	4.53677285	1.86175482	0.68777529	0.00310975	0.00666453	0.00293506	-0.1818	0.0021	-0.0048
	4.53677285	1.98169552	0.10978647	0.00310975	0.00728191	0.00004112	-0.0336	0.0147	-0.0018
2434120.5	4.40361905	2.12452573	0.80376102	0.00355464	0.00647000	0.00286236	-0.3359	-0.0155	-0.0100
	4.40361905	2.26891980	0.10790875	0.00355464	0.00707470	0.00005174	-0.0619	0.0277	-0.0021
2434160.5	4.25331864	2.37902492	0.91661754	0.00396687	0.00625040	0.00277846	-0.4125	-0.0729	-0.0351
	4.25331864	2.56731023	0.10563045	0.00396687	0.00684039	0.00006213	-0.0747	0.0288	-0.0023
2434200.5	4.08848992	2.62428197	1.02591318	0.00437155	0.00600810	0.00268439	-0.3790	-0.1593	-0.0916
	4.08848992	2.81580481	0.10294176	0.00437155	0.00659012	0.00007225	-0.0678	0.0071	-0.0029
24342-0.5	3.90383500	2.85937390	1.13123484	0.00475832	0.00576286	0.00258005	-0.2646	-0.3604	-0.1565
	3.90383500	3.07339233	0.09985443	0.00475802	0.00629527	0.00008205	-0.0907	-0.0292	-0.0019
2434280.5	3.70611140	3.08342952	1.23219021	0.00512473	0.00545651	0.00246618	-0.1755	-0.4423	-0.2011
	3.70611140	3.31911749	0.09638177	0.00512473	0.00598794	0.00009151	-0.0913	-0.0492	-0.0035
2434320.5	3.49413803	3.29563189	1.33284879	0.00547029	0.00515044	0.00234331	-0.3796	-0.4647	-0.2068
	3.49413803	3.55208331	0.09251058	0.00547029	0.00565786	0.00010058	-0.0839	-0.0662	-0.0025
2434360.5	3.26878735	3.49522040	1.41954321	0.00579338	0.00482407	0.00221206	-0.3187	-0.3490	-0.1451
	3.26878735	3.77145407	0.08834112	0.00579338	0.00530775	0.00010972	-0.0548	-0.0524	0.0002
2434400.5	3.03098372	3.68149498	1.50527020	0.00609275	0.00448500	0.00207305	0.0536	-0.2342	-0.1054
	3.03098372	3.97645822	0.08380710	0.00609275	0.00493953	0.00011740	-0.0343	-0.0397	-0.0013
2434440.5	2.78169677	3.85381976	1.58529350	0.00636739	0.00412887	0.00192690	0.0125	-0.1684	-0.0833
	2.78169677	4.16639513	0.07895554	0.00636739	0.00455469	0.00012509	-0.0297	-0.0229	-0.0023
2434480.5	2.52193451	4.01162720	1.65934484	0.00361640	0.00375943	0.00177458	-0.1400	-0.1791	-0.0868
	2.52193491	4.34063715	0.07380673	0.00361640	0.00415511	0.00013226	-0.0482	0.0042	-0.0024
2434520.5	2.25273421	4.15441930	1.72718526	0.00683915	0.00337837	0.00161655	-0.2377	-0.2650	-0.1205
	2.25273421	4.49863231	0.06838171	0.00683919	0.00376266	0.00013889	-0.0732	0.0147	-0.0024
2434560.5	1.97515614	4.28170469	1.78800368	0.00703520	0.00298735	0.00145380	-0.2153	-0.2930	-0.1180
	1.97515614	4.63990062	0.06270239	0.00703520	0.00331907	0.00014497	-0.0744	0.0149	0.0007
2434600.5	1.69028059	4.39329767	1.84341726	0.00720400	0.00258806	0.00128642	-0.3856	-0.3020	-0.1246
	1.69028059	4.76403463	0.05679138	0.00720400	0.00288623	0.00015047	-0.1664	-0.0096	-0.0001
2434640.5	1.39920333	4.48872095	1.89147121	0.00734523	0.00210215	0.00111574	0.3876	-0.2753	-0.1449
	1.39920333	4.87069929	0.05067203	0.00734523	0.00244592	0.00015538	-0.0540	-0.0335	-0.0052
2434680.5	1.10303193	4.56780553	1.93264022	0.00745870	0.00177141	0.00094230	0.2465	-0.2444	-0.1370
	1.10303193	4.95963472	0.04436833	0.00745870	0.00200008	0.00015970	-0.3432	-0.0593	-0.0060
2434720.5	0.80287658	4.63039186	1.98482863	0.00754444	0.00135751	0.00076683	0.2459	-0.1664	0.1018
	0.80287658	5.03065652	0.03790448	0.00754444	0.00155054	0.00016339	-0.0283	-0.0633	-0.0055
2434760.5	0.49954492	4.67638671	1.99336960	0.00764256	0.00094212	0.00059005	0.3065	-0.0943	-0.0450
	0.49954492	5.08065297	0.03130434	0.00764256	0.00108148	0.00016458	-0.0274	-0.0111	-0.0037
2434800.5	0.19503571	4.70576173	2.01402408	0.00763335	0.00052674	0.00041261	0.2502	0.1131	0.0304
	0.19503571	5.11358201	0.02693396	0.00763335	0.00064744	0.00016896	0.0245	-0.0479	-0.0031
2434840.5	-0.11346228	4.71854872	2.02697909	0.00763707	0.00011297	0.00023519	0.1402	-0.1141	0.0214
	-0.11346228	5.13546783	0.01779625	0.00763707	0.00019722	0.00017082	0.0215	-0.0278	-0.0049
2434880.5	-0.41557477	4.71484077	2.03284833	0.00761415	-0.00029774	0.00005643	0.3519	0.4041	-0.0247
	-0.41557477	5.13440126	0.01093627	0.00761415	0.00024991	0.00017207	-0.0020	-0.0130	-0.0047
2434920.5	-0.71924576	4.69478995	2.03186710	0.00756510	-0.00070392	-0.00011702	-0.3208	-0.1307	-0.0672
	-0.71924576	5.11553746	0.00403848	0.00756510	0.00069236	0.00017271	-0.3276	0.0079	-0.0019
2434960.5	-1.02044377	4.65866411	2.02351213	0.00749062	-0.00110418	-0.00029056	0.3569	-0.2844	-0.1345
	-1.02044377	5.07909483	0.00261208	0.00749062	0.00112862	0.00017276	-0.0583	0.0099	-0.0035
2435000.5	-1.31816581	4.60655040	2.00855909	0.00739142	-0.00148731	0.00041363	0.3084	-0.2631	-0.1398
	-1.31816581	5.02534765	0.00977685	0.00739142	0.00155736	0.00017223	-0.0609	-0.0050	-0.0043
2435040.5	-1.61143772	4.53893262	1.98662110	0.00726824	-0.00188210	-0.00062972	0.2447	-0.1976	-0.1045
	-1.61143772	4.95462370	0.01666369	0.00726824	0.00197726	0.00017112	-0.0552	-0.0314	-0.0031
2435080.5	-1.89931543	4.45610809	1.95812 4	0.00712182	-0.00225745	-0.00079433	0.3715	-0.1159	-0.0865
	-1.89931543	4.86730033	0.02345[illegible]	0.00712182	0.00238711	0.00016944	-0.0510	-0.0564	-0.0061
2435120.5	-2.18088517	4.35847795	1.92312783	0.00695300	-0.00262219	-0.00095493	0.3906	-0.0381	-0.0387
	-2.18088517	4.77760515	0.03019214	0.00695300	-0.00278565	0.00016722	-0.0398	-0.0638	-0.0037
2435160.5	-2.45526931	4.24648768	1.88179184	0.00676271	-0.00297529	-0.00111107	0.2757	0.0830	0.0135
	-2.45526931	4.68411428	0.04082784	0.00676271	-0.00311771	0.00016447	-0.0108	-0.0536	-0.0038
2435200.5	-2.71262905	4.12615905	1.83430758	0.00651194	-0.00331375	-0.00126228	0.1518	-0.0847	-0.0070
	-2.71262905	4.51024848	0.04384310	0.00651194	-0.00354423	0.00016121	-0.0023	-0.0323	-0.0049
2435240.5	-2.97916791	3.98140609	1.78087938	0.00632182	-0.00364280	-0.00140821	0.0592	0.0394	-0.0040
	-2.97916791	4.36126745	0.04971796	0.00632182	-0.00390234	0.00015745	-0.0010	-0.0130	-0.0036
2435280.5	-3.22712913	3.82938859	1.72172564	0.00607325	-0.00395563	-0.00154850	0.0131	-0.1017	-0.0601
	-3.22712913	4.17826484	0.05393305	0.00607325	-0.00424518	0.00015322	-0.0191	0.0115	-0.0026
2435320.5	-3.46479607	3.66515306	1.65707868	0.00580727	-0.00429358	-0.00168282	0.0367	-0.2361	-0.1252
	-3.46479607	4.02186728	0.06196977	0.00580727	-0.00457196	0.00014853	-0.0426	0.0275	-0.0035
2435360.5	-3.69149190	3.48931006	1.58718371	0.00552487	-0.00453590	-0.00181084	0.0213	-0.2845	-0.1453
	-3.69149190	3.83273253	0.06781017	0.00552487	-0.00488190	0.00014341	-0.0460	0.0387	-0.0032
2435400.5	-3.90658271	3.30249795	1.51229912	0.00522721	-0.00480195	-0.00191326	0.0500	-0.2676	-0.1395
	-3.90658271	3.63156903	0.07343730	0.00522721	-0.00517429	0.00013787	-0.0430	0.0324	-0.0050
2435440.5	-4.10947949	3.10537741	1.43269396	0.00491535	-0.00505123	-0.00204483	0.0972	-0.1307	-0.0774
	-4.10947949	3.41902995	0.07883513	0.00491535	-0.00544858	0.00013195	-0.0321	0.0101	-0.0031
2435480.5	-4.29963660	2.89862886	1.34844691	0.00459040	-0.00528328	-0.00215432	0.1064	0.0018	0.0004
	-4.29963660	3.19591048	0.08398861	0.00459040	-0.00570425	0.00012566	-0.0197	-0.0121	0.0002
2435520.5	-4.47655088	2.68294948	1.26044479	0.00425331	-0.00549770	-0.00225455	0.0249	0.1266	0.0365
	-4.47655088	2.96294427	0.08878350	0.00425337	-0.00594081	0.00011902	0.0095	-0.0229	-0.0033
2435560.5	-4.63976002	2.49905373	1.18838272	0.00390533	-0.00569403	-0.00234720	-0.1446	0.1602	0.0488
	-4.63976002	2.72090426	0.09350626	0.00390533	-0.00615786	0.00011206	0.3388	-0.0131	-0.0042
2435600.5	-4.78884548	2.22767228	1.07276390	0.00354737	-0.00587193	-0.00242235	-0.3417	0.1302	0.0342
	-4.78884548	2.47588144	0.09784434	0.00354737	-0.00638481	0.00010479	0.3676	0.0071	-0.0050
2435640.5	-4.92343330	1.98959428	0.97389843	0.00318065	-0.00603107	-0.00250959	-0.3639	-0.0091	-0.0302
	-4.92343330	2.21278188	0.10188618	0.00318065	-0.00653165	0.00009725	0.3598	0.0311	-0.0056
2435680.5	-5.04319596	1.71543837	0.87210171	0.00280629	-0.00617171	-0.00257891	-0.3011	-0.1211	-0.0616
	-5.04319596	1.94432252	0.10562125	0.00280629	-0.00668789	0.00008946	0.0429	0.0435	-0.0024
2435720.5	-5.14784837	1.44139861	0.76749240	0.00242531	-0.00629248	-0.00264021	-0.2075	-0.2089	-0.1100
	-5.14784837	1.67802651	0.10903989	0.00242531	-0.00682345	0.00008143	0.0229	0.0532	-0.0037
2435760.5	-5.23714650	1.24221492	0.66099269	0.00203873	-0.00639449	-0.00269341	-0.0820	-0.1872	-0.1059

-5.23714650 1.40272362 0..	1213334-C.C0203873-C.00693820 0.00007370	0.0043	0.0420	-0.0043
2435800.5-5.31288555 0.98479731 0.55232777-0.00164753-0.00647715-0.00273845		-0.0439	-0.0894	-0.0492
-5.31288555 1.12325028.0.11489358-C.00164753-0.00703195 0.00006478		0.0040	0.0200	-0.0018
2435840.5-5.36890203 0.72438252 0.44202687-0.00125279-0.00654034-0.00277521		-0.0152	0.0237	0.0038
-5.36890203 0.84044947 0.11731360-0.00125279-0.00710455 0.00005619		0.0034	-0.0038	-0.0012
2435880.5-5.41107595 0.46182979 0.35042145-0.00085557-0.00658403-0.00280367		-0.0284	0.1617	0.0631
-5.41107595 0.55516817 0.11938742-0.00085557-0.00715596 0.00004747		0.0084	-0.0312	-0.0014
2435920.5-5.43732983 0.19791904 0.21784420-0.00045696-0.00660826-0.00282380		-0.1321	0.2073	0.0844
-5.43732983 0.20825435 0.12111005-0.00045696-0.00718620 0.00003864		0.0262	-0.0398	-0.0015
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-5.44762737-0.01944686 0.12247740-0.00005791-0.00719534 0.00002971		0.0455	-0.0354	-0.0041
2436000.5-5.44197059-0.33087054-0.00889552 0.00034558-0.00659857-0.00283914		-0.3105	0.1133	0.0315
-5.44197059-0.30709222 0.12348668 0.00034558-0.00718342 0.00002071		0.0556	-0.0245	-0.0062
2436040.5-5.42240128-0.59420177-0.12230321 0.00073755-0.00656477-0.00283435		-0.3334	0.0326	-0.0060
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2436080.5-5.38300173-0.85579707-0.23553332 0.00113194-0.00651180-0.00282127		-0.1672	-0.0867	-0.0620
-5.38300103-0.87885414 0.12441858 0.00113194-0.00709669 0.00000258		0.0332	0.0139	-0.0049
2436120.5-5.32989383-1.11489335-0.34798534 0.00152273-0.00643987-0.00279997		-0.0346	-0.0915	-0.0636
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2436200.5-5.17726556-1.62258422-0.56951923 0.00228983-0.00624008-0.00273300		0.0605	0.0031	0.0055
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2436240.5-5.07813936-1.86969955-0.67795591 0.00266434-0.00611265-0.00268749		-0.0334	0.1175	0.0639
-5.07613936-1.98507735 0.12193647 0.00266434-0.00667728-0.00003350		-0.0031	-0.0250	0.0022
2436280.5-4.96419615-2.11135542-0.78441323 0.00303151-0.00596716-0.00263405		-0.1563	0.1287	0.0527
-4.96419615-2.24913874 0.12041891 0.00303151-0.00655223-0.00004236		0.0156	-0.0351	-0.0009
2436320.5-4.83572906-2.34683537-0.88857615 0.00339037-0.00580391-0.00257279		-0.2634	0.0551	0.0067
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2436360.5-4.69[illegible]3C9062-2.57543038-0.99013435 0.00373992-0.00552328-0.00250385		-0.3808	-0.1015	-0.0397
-4.69309062-2.75675634 0.11633185 0.00373992-0.00615525-0.00005972		0.0673	-0.0163	-0.0007
2436400.5-4.53667176-2.79647312-1.08878422 0.00407926-0.00542576-0.00242740		-0.3458	-0.2312	-0.0950
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2436440.5-4.36689749-3.00927699-[illegible].18422863 0.00440753-0.00521171-0.00234360		-0.2126	-0.2966	-0.1377
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2436520.5-3.98915899-3.40759566-1.36634418 0.00502735-0.00473581-0.00214462		0.0571	-0.2495	-0.1205
-3.98915899-3.66910108 0.10411843 0.00502735-0.00520208-0.00000241		0.0268	0.0447	-0.0026
2436560.5-3.78222400-3.59189994-1.44843565 0.00531702-0.00447493-0.00204976		0.1142	-0.1459	-0.0663
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2436600.5-3.56399214-3.76739668-1.52823706 0.00559204-0.00419953-0.00193833		0.0615	-0.0601	-0.0015
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2436640.5-3.33506715-3.92763713-1.60343561 0.00585155-0.00391623-0.00132056		-0.0324	0.0666	0.0313
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-2.05348733-4.93240237 0.06561708 0.00688743-0.00254600-0.00014468		0.0350	-0.0013	-0.0018
2436880.5-1.77493753-4.63527554-1.94515637 0.00703661-0.00192025-0.00099581		0.0758	-0.0198	-0.0202
-1.77493753-5.02651417 0.05973060 0.00703661-0.00215793-0.00014956		-0.0001	0.0150	-0.0020
2436920.5-1.49383742-4.70478356-1.98192094 0.00716484-0.00155380-0.00084174		0.1202	0.1180	0.0461
-1.49383742-5.10491139 0.05365738 0.00716484-0.00176042-0.00015402		-0.0292	0.0150	-0.0006
2436960.5-1.20203905-4.75947762-2.01244515 0.00727140-0.00111791-0.00068386		0.1311	0.2012	0.0816
-1.20203905-5.16723472 0.04741506 0.00727140-0.00135440-0.00015801		-0.0455	0.0148	-0.0006
2437000.5-0.90942371-4.79907280-2.03658515 0.00735558-0.00079903-0.00052261		0.0234	0.2813	0.1017
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2437080.5-0.31639632-4.83204251-2.06522647 0.00745440-0.00002231-0.00019179		-0.1669	0.1979	0.0731
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2437120.5-0.01786608-4.82506943-2.06953269 0.00746807 0.00037145-0.00002322		-0.1541	0.1064	0.0329
-0.01786608-5.25012511 0.02113859 0.00746807 0.00033150-0.00016908		-0.0210	-0.0294	-0.0022
2437160.5 0.28072392-4.80230244-2.06706485 0.00745732 0.00076715 0.00014681		-0.0908	-0.0310	-0.0263
0.28072392-5.22825629 0.01434425 0.00745732 0.00078222-0.00017056		0.0065	-0.0177	-0.0023
2437200.5 0.57838891-4.76368684-2.05777505 0.00742176 0.00116367 0.00031779		0.1153	-0.0438	-0.0435
0.57838891-5.19913233 0.00750250 0.00742176 0.00119404-0.00017145		0.0113	0.0017	-0.0043
2437240.5 0.87412925-4.70921636-2.04163650 0.00736103 0.00155984 0.00048915		0.0895	0.0214	-0.0096
0.87412925-5.13273782 0.00063582 0.00736103 0.00162349-0.00017178		-0.0301	0.0175	-0.0033
2437280.5 1.16693377-4.63894159-2.01864600 0.00727496 0.00195365 0.00066029		0.1695	0.1490	0.0596
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2437320.5 1.45578669-4.55296838-1.98624201 0.00716344 0.00234433 0.00083062		0.2198	0.3085	0.1230
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2437360.5 1.73966990-4.45145792-1.95221509 0.00702649 0.00273029 0.00099954		0.1116	0.4163	0.1560
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2437400.5 2.01756674-4.33462632-1.90888695 0.00686412 0.00311015 0.00116848		-0.3530	0.3701	0.1229
2.01756674-4.73625660-0.02661715 0.00686412 0.00331749-0.00016730		-0.0734	0.0201	-0.0071
2437440.5 2.29466133-4.20274657-1.85893187 0.00667640 0.00348244 0.00133078		-0.2115	0.3056	0.0881
2.29466133-4.59538901-0.03325900 0.00667640 0.00372441-0.00016469		-0.0733	-0.0095	-0.0084
2437480.5 2.55134410-4.05615234-1.80246831 0.00644357 0.00384562 0.00140179		-0.2885	0.1716	0.0451
2.55134410-4.43843228-0.03978434 0.00644357 0.00412167-0.00016147		-0.0577	-0.0118	-0.0057
2437520.5 2.80521744-3.89723932-1.73986158 0.00622600 0.00419811 0.00164882		-0.1969	0.0589	0.0006
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2437560.5 3.04910296-3.72046579-1.67062443 0.00596429 0.00455841 0.00180121		-0.0886	-0.0044	-0.0274
3.04910296-4.07800281-0.05238926 0.00596429 0.00488037-0.00015325		-0.0080	-0.0157	-0.0047
2437600.5 3.28204697-3.53234866-1.59581543 0.00567904 0.00486504 0.00194830		-0.3270	-0.0462	-0.0402
3.28204697-3.87557253-0.05842148 0.00567904 0.00523856-0.00014826		0.0054	-0.0115	-0.0036
2437640.5 3.50312310-3.33146366-1.51703896 0.00537103 0.00571657 0.00238948		-0.0148	0.0905	-0.0165
3.50312310-3.65913379-0.06424253 0.00537103 0.00558054-0.00014269		-0.0011	-0.0030	-0.0010

2437640.52437640.5 HOLD YOUR HAT, TMAX HAS BEEN REACHED

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                                        STPRG2          STEPWISE REGRESSION PROGRAM

        N     MTOTAL          SDIN          SDOUT          DIAG

        6        110  10.0000000E-18   0.            10.0000000E-09

NO. OF COEFFS IN REGRESSION =  0     SUM OF SQUARED RESIDUALS =  3.42265E-15     S.D. OF DATA =  5.57809E-09

                COEFFS IN REGRESSION                                                COEFFS NOT IN REGRESSION

INDEX             COEFF            S.D.      COEFF/S.D.                    INDEX   PREDICTED (COEFF/S.D.)

                                                                               1        3.1896E-06
                                                                               2        3.1866E-07
                                                                               3        1.5855E-07
                                                                               4        1.5005E-05
                                                                               5        7.1163E-06
                                                                               6        1.3139E-05

                                        INTRODUCING COEFF NO.

NO. OF COEFFS IN REGRESSION =  1     SUM OF SQUARED RESIDUALS =  3.42265E-15     S.D. OF DATA =  5.60362E-09

                COEFFS IN REGRESSION                                                COEFFS NOT IN REGRESSION

INDEX             COEFF            S.D.      COEFF/S.D.                    INDEX   PREDICTED (COEFF/S.D.)

                                                                               1        1.8481E-06
                                                                               2        3.1689E-07
                                                                               3        1.5763E-07
    4      5.0808825E-15      3.3861E-10      1.5003E-05                     5        1.0681E-05
                                                                               6        1.2943E-05

                                        INTRODUCING COEFF NO.   6

NO. OF COEFFS IN REGRESSION =  2     SUM OF SQUARED RESIDUALS =  3.42265E-15     S.D. OF DATA =  5.62950E-09

                COEFFS IN REGRESSION                                                COEFFS NOT IN REGRESSION

INDEX             COEFF            S.D.      COEFF/S.D.                    INDEX   PREDICTED (COEFF/S.D.)

                                                                               1        1.6187E-06
                                                                               2        3.1541E-07
                                                                               3        1.5689E-07
    4      5.0407851E-15      3.4019E-10      1.4817E-05                     5        8.1443E-06
    6      4.2479131E-15      3.3902E-10      1.2743E-05

                                        INTRODUCING COEFF NO.   5

NO. OF COEFFS IN REGRESSION =  3     SUM OF SQUARED RESIDUALS =  3.42265E-15     S.D. OF DATA =  5.65574E-09

                COEFFS IN REGRESSION                                                COEFFS NOT IN REGRESSION

INDEX             COEFF            S.D.      COEFF/S.D.                    INDEX   PREDICTED (COEFF/S.D.)

                                                                               1        1.2352E-05
                                                                               2        3.1388E-07
                                                                               3        1.5611E-07
    4      5.6961259E-15      3.5112E-10      1.6223E-05
    5      8.4678435E-16      1.0397E-10      8.1443E-06
    6      3.8019348E-15      3.4812E-10      1.0921E-05

                                        INTRODUCING COEFF NO.   1

NO. OF COEFFS IN REGRESSION =  4     SUM OF SQUARED RESIDUALS =  3.42265E-15     S.D. OF DATA =  5.68236E-09

                COEFFS IN REGRESSION                                                COEFFS NOT IN REGRESSION

INDEX             COEFF            S.D.      COEFF/S.D.                    INDEX   PREDICTED (COEFF/S.D.)

    1      1.4736584E-14      1.1931E-09      1.2352E-05
                                                                               2        3.1225E-07
                                                                               3        1.5526E-07
    4      8.4908241E-15      4.1910E-10      2.0263E-05
    5      3.3775266E-15      2.2998E-10      1.4686E-05
    6      2.2103935E-15      3.7273E-10      5.9302E-06

                                        INTRODUCING COEFF NO.   2

NO. OF COEFFS IN REGRESSION =  5     SUM OF SQUARED RESIDUALS =  3.42265E-15     S.D. OF DATA =  5.70935E-09

                COEFFS IN REGRESSION                                                COEFFS NOT IN REGRESSION

INDEX             COEFF            S.D.      COEFF/S.D.                    INDEX   PREDICTED (COEFF/S.D.)

    1      1.4736580E-14      1.1927E-09      1.2294E-05
    2      2.3961222E-16      7.6737E-10      3.1229E-07
                                                                               3        1.5862E-07
    4      8.4908214E-15      4.2109E-10      2.0164E-05
    5      3.3715257E-15      2.3107E-10      1.4617E-05
    6      2.2103941E-15      3.7450E-10      5.9022E-06

                                        INTRODUCING COEFF NO.   3

NO. OF COEFFS IN REGRESSION =  6     SUM OF SQUARED RESIDUALS =  3.42265E-15     S.D. OF DATA =  5.73674E-09

                COEFFS IN REGRESSION                                                COEFFS NOT IN REGRESSION

INDEX             COEFF            S.D.      COEFF/S.D.                    INDEX   PREDICTED (COEFF/S.D.)

    1      1.4736578E-14      1.2045E-09      1.2235E-05
    2      2.4121979E-16      7.7112E-10      3.1282E-07
    3     -1.2310793E-16      7.7612E-10     -1.5862E-07
    4      8.4908203E-15      4.2311E-10      2.0068E-05
    5      3.3775253E-15      2.3218E-10      1.4547E-05
    6      2.2103943E-15      3.7630E-10      5.8740E-06

  LITTLE  OMEGA  TILTA

       1.7359537764364776-14
   THIS  IS  POR  PATRIX

       9.7134944901787390-01          2.3656338075051911-01          2.2759938064332857-02
      -2.3659164907684363-01          9.7160804703533210-01          1.4813923471328043-03
       2.2464182152272161-02          3.9458616386506590-03          9.9973986151206751-01
   ELEMTS

       5.2026354205759066 00          1.4502773936048945-03          4.8910758649332477-02          2.2810075291063532-02
       1.7446738198328020 00          4.7773850148968733 00          5.2796469381664117 00
```

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 XSOLVE

     1.473657827534960E-14        2.412197311855871E-16       -1.231075366049470E-16        8.490820360186540E-15
     3.377525286742351E-15        2.210394316378423E-15
 NEW  PQR

     9.713494490178326E-01        2.365633807506885E-01       -2.275993806133217E-02
    -2.365916490770130E-01        9.716080470352910E-01        1.481392347137094E-03
     2.266418215227209E-02        3.945861638650405E-03        9.997398615120625E-01
 ELLIPTICAL  CORRECTIONS

     1.757210924126286E-14        0.000000000000000E 00        2.210394316378423E-15       -1.071803017998109E-16
    -1.090429955339921E-14        1.844998771768869E-13       -1.588616359961113E-13
 NEW    ELEMENTS

     5.202655420575923E 00        1.453277393604587E-03        4.891075864933488E-02        2.281007529106342E-02
     1.744673819832790E 00        4.777385014897057E 00        5.279646938166251E 00
 KEPLERS  3 RD  LAW  MU

     2.961947411500787E-04

RMS  DIFFERENCE  NEGLIGIBLE
RMS(I+1)=  0.55780859E-08
RMS(I)  =  0.55780866E-08

PLOD  HAS  CONVERGED  AT      5  ITERATIONS

AND  A  SIGMA  VALUE  OF.....  0.55780859E-08

        JULIAN  DATE.....  2437680.50

        ELAPSED  TIME  IN  DAYS.....      4400.00

        NUMBER  OF  INTEGRATION  STEPS..        110.

        SIGMA  SQUARE  X  N.....  0.34226947E-14

        X  =      3.50312310  Y  =     -3.33146366  Z  =     -1.51483896

PLOD  WILL  BEGIN  TO  WRITE  AN  EPHEMERIS


 ***  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....      DELTA  X         DELTA  Y         DELTA  Z
MEAN  DEVIATION  .....MD=SUM(DELTA)/N     -0.430834C8E-08 -0.836341788-09 -0.176842308-08
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  0.322376338-15  0.427687858-15  0.776769548-16
STANDARD  DEVIATION.....SD=SQRT(SR-MD**2)  0.174302768-07  0.206836898-07  0.863421308-08
MAXIMUM  RESIDUAL .....  0.390571918-07  0.525074828-07  0.191168458-07
MINIMUM  RESIDUAL ..... -0.412527408-07 -0.466467038-07 -0.236761018-07

****  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....  RADIUS VECTOR        COSB  DL        DLAT*DB
MEAN  DEVIATION  .....MD=SUM(DELTA)/N     -0.153404428-08  0.333336708-13 -0.287105358-09
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N  0.181126538-16  0.128769178-16  0.125471998-18
STANDARD  DEVIATION.....SD=SQRT(SR-MD**2)  0.134980628-08  0.358844228-08  0.207466888-09
MAXIMUM  RESIDUAL .....  0.783577028-08  0.106487568-07  0.416777428-09
MINIMUM  RESIDUAL ..... -0.913673348-08 -0.637846348-08 -0.841416698-09

 ECLIPTIC  POS-VEL  FROM  TRANSX AND EQUATORIAL  POS-VEL  AFTER  ROTATION  FROM  ECLIPTIC

      3.349356648772082E 00       -3.812496654317168 00       -6.021264573354245E-02
      5.585654978763444E-03        5.345235489919946E-03       -1.466068686410450E-04
      3.349356648772082E 00       -3.473765997460115 00       -1.572161202521209 00
      5.585654978763444E-03        4.962248671793407E-03        1.992266080601939E-03

 BEGIN  ITERATION


 EPOCH  VALUES  EQUATORIAL    2433280.50

      3.349356648772082E 00       -3.471765997460115 00       -1.572161202521280 00
      5.585654978763444E-03        4.962248671793407E-03        1.992266080601939E-03

 ELEMENTS  CHECK  FROM  SUBR  ELEMTS

      5.202655420575903E 00        1.453277393604596E-03        4.891075864933361E-02        4.058471467314245E-01
      5.693130520756984E-02        1.866023825239782E-01        5.279646938166214E 00

 TRANSPOSE  PQR  MATRIX  CHECK

      9.713494490178241E-01        2.263877382127492E-01        7.324331042908147E-02
     -2.365916490770481E-01        8.907997073096753E-01        3.879436467375106E-01
      2.266418215227212E-02       -3.941576331067248E-01        9.187682757003463E-01

 ECLIPTIC  ELEMENTS

      5.202655420575903E 00        1.453277393604596E-03        4.891075864933361E-02        2.281007529106349E-02
      1.744673819832791E 00        4.777385014897092E 00        5.279646938166214E 00

 ECLIPTIC  PQR  MATRIX

      9.713494490178241E-01        2.365633807507233E-01       -2.275993806133215E-02
     -2.365916490770481E-01        9.716080470352821E-01        1.481392347137899E-03
      2.266418215227212E-02        3.945861638650468E-03        9.997398615120657E-01
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EPHEMERIS FORMAT FOR EACH JULIAN DATE IS

JUL-DATE	EQUA. X ECLP. X	EQUA. Y ECLP. Y	EQUA. Z ECLP. Z	EQUA XDOT ECLP XDOT	EQUA YDOT ECLP YDOT	EQUA ZDOT ECLP ZDOT	TPFDX TPFDP	TPFDY TPFCOSBDL	TPFDZ TPFDB
2433280.5	3.34935862	-3.47376597	-1.5726[illegible]120	0.00558565	0.00496224	0.00199226	0.2802	0.3842	0.1179
	3.34935862	-3.81249464	-0.06021264	0.00558565	0.00534523	-0.00014681	-0.0244	0.0950	-0.0037
2433320.5	3.56656304	-3.26908711	-1.48966344	0.00527099	0.00526898	0.00213154	-0.2218	0.5097	0.1841
	3.56656304	-3.59189036	-0.06596402	0.00527099	0.00568207	-0.00014087	-0.0450	0.1065	-0.0069
2433360.5	3.77074730	-3.05247253	-1.40172687	0.00493468	0.00455880	0.00228410	0.1417	0.5251	0.1912
	3.77074730	-3.35817185	-0.07147464	0.00493468	0.00600069	-0.00013456	-0.0524	0.1011	-0.0074
2433400.5	3.96106216	-2.82462826	-1.30963363	0.00457770	0.00583023	0.00238920	-0.0062	0.4622	0.1617
	3.96106216	-3.11209965	-0.07672238	0.00457770	0.00629952	-0.00012773	-0.0607	0.0755	-0.0080
2433440.5	4.13670254	-2.58631727	-1.21369123	0.00420115	0.00608190	0.00250645	-0.1091	0.2982	0.1153
	4.13670254	-2.85449430	-0.08[illegible]58588	0.00420115	0.00657703	-0.00012036	-0.0539	0.0400	-0.0034
2433480.5	4.29691118	-2.33835801	-1.1[illegible]723224	0.00380635	0.00631242	0.00261500	-0.1539	0.2095	0.0772
	4.29691118	-2.58624080	-0.08634456	0.00380635	0.00683171	-0.00011249	-0.0490	0.0220	-0.0032
2433520.5	4.44098741	-2.08162171	-1.00161344	0.00339478	0.00652057	0.00271436	-0.1466	0.1134	0.0355
	4.44098741	-2.30827981	-0.09067906	0.00339478	0.00706220	-0.00010415	-0.0368	-0.0074	-0.0032
2433560.5	4.56829089	-1.81702571	-0.89121273	0.00296798	0.00670522	0.00280401	-0.0275	0.0767	0.0228
	4.56829089	-2.02160332	-0.09467115	0.00296798	0.00726728	-0.00009537	-0.0114	0.0124	-0.0021
2433600.5	4.67824543	-1.54553045	-0.77742817	0.00252761	0.00686537	0.00288348	0.0047	0.0920	0.0301
	4.67824543	-1.72725080	-0.09830384	0.00252761	0.00744583	0.00008619	0.0055	0.0226	-0.0017
2433640.5	4.77034098	-1.26813509	-0.66067580	0.00207533	0.00700007	0.00295232	0.0837	0.1241	0.0472
	4.77034098	-1.42630446	-0.10156130	0.00207533	0.00759679	-0.00007662	0.0087	0.0296	-0.0007
2433680.5	4.84413850	-0.98587618	-0.54138952	0.00161303	0.00710843	0.00301012	0.0336	0.2430	0.0997
	4.84413850	-1.11988793	-0.10442916	0.00161303	0.00771920	-0.00006671	-0.0053	0.0530	-0.0012
2433720.5	4.89927614	-0.89982120	-0.42001837	0.00114267	0.00718976	0.00305651	-0.0466	0.3266	0.1173
	4.89927614	-0.98915924	-0.10689447	0.00114267	0.00781228	-0.00005651	-0.0205	0.0673	-0.0049
2433760.5	4.93547189	-0.81106296	-0.29702434	0.00066629	0.00724352	0.00309122	-0.1353	0.2751	0.0900
	4.93547189	-0.89530476	-0.10896688	0.00066629	0.00787541	-0.00004606	-0.0328	0.0551	-0.0061
2433800.5	4.95252675	-0.72071150	-0.17287888	0.00018595	0.00726937	0.00311405	-0.1693	0.1273	0.0350
	4.95252675	-0.17953044	-0.11057844	0.00018595	0.00790821	-0.00003539	-0.0342	0.0251	-0.0045
2433840.5	4.95032227	0.17011061	-0.04806066	0.00029631	0.00726701	0.00312483	-0.1723	-0.0531	-0.0342
	4.95032227	0.13694333	-0.11177644	0.00029631	0.00791034	-0.00002456	-0.0351	-0.0116	-0.0024
2433880.5	4.92882407	0.46027218	0.07694589	0.00077838	0.00723632	0.00312345	-0.1728	-0.2250	-0.1036
	4.92882407	0.45288602	-0.11254063	0.00077838	0.00788163	-0.00001382	-0.0393	-0.0466	-0.0021
2433920.5	4.88808244	0.74863854	0.20165287	0.00125811	0.00717726	0.00310985	-0.1198	-0.4051	-0.0877
	4.88808244	0.76706234	-0.11180539	0.00125811	0.00782264	-0.00000261	-0.0309	-0.0408	-0.0005
2433960.5	4.82823676	1.03407814	0.32557133	0.00173322	0.00709065	0.00308405	-0.0439	-0.1413	-0.0725
	4.82823676	1.07824020	-0.11274906	0.00173322	0.00773176	0.00000842	-0.0156	-0.0293	-0.0024
2434000.5	4.74951452	1.31547238	0.44821580	0.00220158	0.00697508	0.00304617	0.0264	-0.0992	-0.0436
	4.74951452	1.38519961	-0.11219198	0.00220158	0.00761121	0.00001942	-0.0010	-0.0225	-0.0001
2434040.5	4.65222859	1.59172219	0.56910703	0.00266107	0.00683294	0.00299643	-0.0263	-0.0210	-0.0131
	4.65222859	1.68674174	-0.11119650	0.00266107	0.00746101	0.00003033	-0.0067	-0.0028	-0.0009
2434080.5	4.53677285	1.86175482	0.68777529	0.00310975	0.00666433	0.00293506	-0.1818	0.0021	-0.0648
	4.53677285	1.98169552	-0.10976674	0.00310975	0.00728191	0.00004112	-0.0336	0.0147	-0.0018
2434120.5	4.40361905	2.12452573	0.80376102	0.00354564	0.00647000	0.00286236	-0.1359	-0.0155	-0.0105
	4.40361905	2.20891980	-0.10780875	0.00354564	0.00707670	0.00005174	-0.0519	0.0277	-0.0021
2434160.5	4.25331664	2.37902492	0.91611744	0.00396687	0.00625090	0.00277866	-0.4125	-0.0729	-0.0351
	4.25331664	2.54731023	-0.10563045	0.00396687	0.00684039	0.00006213	-0.0797	-0.0288	-0.0023
2434200.5	4.08648992	2.62428197	1.02591318	0.00437155	0.00600810	0.00268439	-0.3790	-0.1983	-0.0916
	4.08648992	2.81580481	-0.10294176	0.00437155	0.00658012	0.00007225	-0.0878	0.0071	-0.0029
2434240.5	3.90383500	2.85937390	1.13123484	0.00475802	0.00574286	0.00258005	-0.2646	-0.3604	-0.1565
	3.90383500	3.07339233	-0.09985443	0.00475802	0.00629527	0.00008205	-0.0907	-0.0292	-0.0019
2434280.5	3.70611140	3.08342952	1.23219021	0.00512473	0.00545651	0.00246616	-0.1755	-0.4423	-0.2011
	3.70611140	3.31911749	-0.09638177	0.00512473	0.00598724	0.00009151	-0.0913	-0.0492	-0.0035
2434320.5	3.49413803	3.29563189	1.32840879	0.00547029	0.00515044	0.00234331	-0.1796	-0.4647	-0.2068
	3.49413803	3.55208321	-0.09253860	0.00547029	0.00565756	0.00010058	-0.0839	-0.0682	-0.0025
2434360.5	3.26878735	3.49522140	1.42954321	0.00579338	0.00482607	0.00221187	-0.2187	-0.3492	-0.1651
	3.26878735	3.77145407	-0.08834112	0.00579338	0.00530775	0.00010922	-0.0546	-0.0524	-0.0002
2434400.5	3.03098372	3.68149498	1.50527020	0.00609275	0.00448550	0.00207305	0.0536	-0.2342	-0.1094
	3.03098372	3.97645822	-0.08380710	0.00609275	0.00493953	0.00011740	-0.0343	-0.0397	-0.0013
2434440.5	2.78169677	3.85381976	1.58529350	0.00636739	0.00412887	0.00192699	0.0125	-0.1684	-0.0833
	2.78169677	4.16639513	0.07892354	0.00636739	0.00455469	0.00012509	-0.0297	-0.0229	-0.0023
2434480.5	2.52193451	4.01162720	1.65934484	0.00661640	0.00375943	0.00177458	-0.1400	-0.1791	-0.0868
	2.52193451	4.34063715	0.07380673	0.00661640	0.00415511	0.00013226	-0.0482	0.0042	-0.0024
2434520.5	2.25273421	4.15441930	1.72718526	0.00683919	0.00337837	0.00161655	-0.2377	-0.2600	-0.1205
	2.25273421	4.49863231	-0.06838171	0.00683919	0.00374264	0.00013889	-0.0720	0.2167	-0.0024
2434560.5	1.97515614	4.28176439	1.78860368	0.00703520	0.00298735	0.00145360	-0.2159	-0.2930	-0.1180
	1.97515614	4.63990062	-0.06270239	0.00703520	0.00330907	0.00013147	-0.0744	0.0149	0.0007
2434600.5	1.69028059	4.39329767	1.84341726	0.00720400	0.00258806	0.00128642	-0.0656	-0.3000	-0.1266
	1.69028059	4.76403463	-0.05679138	0.00720400	0.00288623	0.00015047	-0.0664	-0.0056	-0.0001
2434640.5	1.39920333	4.48872095	1.89147121	0.00734523	0.00218215	0.00111574	0.0876	-0.2753	-0.1449
	1.39920333	4.87069929	-0.05067203	0.00734523	0.00244592	0.00015538	-0.0540	-0.0335	-0.0052
2434680.5	1.10303193	4.56780553	1.93264022	0.00745870	0.00177141	0.00094230	0.2465	-0.2444	-0.1370
	1.10303193	4.95963472	-0.04436833	0.00745870	0.00200308	0.00015970	-0.0430	-0.0593	-0.0060
2434720.5	0.80287658	4.63039166	1.96682863	0.00754444	0.00135751	0.00076683	0.2959	-0.1664	-0.1018
	0.80287658	5.03065652	-0.03790448	0.00754444	0.00155054	0.00016339	-0.0283	-0.0633	-0.0055
2434760.5	0.49984492	4.67638671	1.99396960	0.00760256	0.00094212	0.00059005	0.3065	-0.1563	-0.0450
	0.49984492	5.08365497	-0.03130490	0.00760256	0.00109610	0.00016448	-0.0076	-0.0611	-0.0037
2434800.5	0.19503571	4.70573173	2.01402408	0.00763335	0.00052676	0.00041261	0.2502	-0.1131	0.0308
	0.19503571	5.11858201	-0.02459396	0.00763335	0.00064744	0.00016896	0.0245	-0.0479	-0.0031
2434840.5	-0.11046228	4.71834872	2.02697909	0.00763707	0.00011297	0.00023519	0.1402	0.1141	0.0214
	-0.11046228	5.13046783	-0.01779625	0.00763707	0.00019722	0.00017082	0.0215	-0.0278	-0.0049
2434880.5	-0.41557477	4.71484077	2.03284833	0.00761415	-0.00029774	0.00005843	0.0519	0.0041	-0.0247
	-0.41557477	5.13440126	-0.01093627	0.00761415	0.00024991	0.00017207	-0.0020	-0.0100	-0.0047
2434920.5	-0.71924576	4.69478995	2.03167108	0.00756510	-0.00070392	-0.00011702	-0.0208	-0.1307	-0.0672
	-0.71924576	5.11553746	-0.00403848	0.00756510	0.00069236	0.00017271	-0.0276	0.0079	-0.0019
2434960.5	-1.02044377	4.65860611	2.02351213	0.00749062	-0.00110418	-0.00029056	0.0069	-0.2644	-0.1343
	-1.02044377	5.07909483	0.00287308	0.00749062	0.00112862	0.00017276	-0.0563	0.0099	-0.0035
2435000.5	-1.31816581	4.60455042	2.00845909	0.00739142	-0.00149731	-0.00046163	0.1084	-0.2631	-0.1308
	-1.31816581	5.02534765	0.00977485	0.00739142	0.00155736	0.00017223	-0.0609	-0.0056	-0.0043
2435040.5	-1.61143772	4.53893262	1.98662110	0.00726424	-0.00188210	-0.00062972	0.2447	-0.1976	-0.1045
	-1.61143772	4.95462370	0.01664369	0.00726824	0.00197726	0.00017112	-0.0552	-0.0314	-0.0031
2435080.5	-1.89931543	4.45610809	1.95812744	0.00712182	-0.00225745	-0.00079433	0.3715	-0.1159	-0.0865
	-1.89931543	4.86730033	0.02345689	0.00712182	0.00238711	0.00016944	-0.0510	-0.0564	-0.0061
2435120.5	-2.18088517	4.35847795	1.92312783	0.00695300	-0.00262219	-0.00095493	0.3906	-0.0381	-0.0387
	-2.18088517	4.76386515	0.03019214	0.00695300	0.00278565	0.00016722	-0.0398	-0.0638	-0.0037
2435160.5	-2.45526931	4.24648768	1.88179186	0.00676271	-0.00297529	-0.00111107	0.2757	0.0830	0.0139
	-2.45526931	4.64461428	0.03682784	0.00676271	0.00317171	0.00016447	-0.0108	-0.0536	-0.0038
2435200.5	-2.72162905	4.12062317	1.83430758	0.00655196	-0.00331575	-0.00126622	0.1518	-0.0817	0.0070
	-2.72162905	4.51024848	0.04334310	0.00655196	0.00354423	0.00016121	-0.0223	-0.0323	-0.0049
2435240.5	-2.97916791	3.98140609	1.78087938	0.00632182	-0.00364280	-0.00140821	0.3592	0.0394	-0.0040
	-2.97916791	4.36126745	0.04971796	0.00632182	0.00390234	0.00015745	-0.0010	-0.0130	-0.0036
2435280.5	-3.22712913	3.82938859	1.72172564	0.00607325	-0.00395565	-0.00154850	0.0131	-0.1017	-0.0601
	-3.22712913	4.19826484	0.05593305	0.00607325	0.00424518	0.00015322	-0.0191	0.0115	-0.0026
2435320.5	-3.44679607	3.64513306	1.65707868	0.00580727	-0.00425358	-0.00168282	0.3367	-0.2361	-0.1252
	-3.44679607	4.02186728	0.06196977	0.00580727	0.00457196	0.00014853	-0.0426	0.0275	-0.0035
2435360.5	-3.69149190	3.48931006	1.58718371	0.00552487	-0.00453590	-0.00181084	0.3213	-0.2845	-0.1453
	-3.69149190	3.83275353	0.06781017	0.00552487	0.00488190	0.00014341	-0.0460	0.0387	-0.0032
2435400.5	-3.90658271	3.30249795	1.51229912	0.00522721	-0.00480195	-0.00193226	0.3500	-0.2476	-0.1398
	-3.90658271	3.63154903	0.07343730	0.00522721	0.00517429	0.00013787	-0.0430	0.0324	-0.0030
2435440.5	-4.10947949	3.1053774[illegible]	1.43269396	0.00491535	0.00505123	0.00204883	0.0972	-0.1307	-0.0776
	-4.10947949	3.41902955	0.07883513	0.00491535	0.00544838	0.00013195	-0.0321	0.0101	-0.0031
2435480.5	-4.29963660	2.89862886	1.34864491	0.00459040	0.00528328	0.00215432	0.1064	0.0018	0.0004
	-4.29963660	3.19591048	0.08398861	0.00459040	0.00570425	0.00012566	-0.0157	-0.0121	0.0002
2435520.5	-4.47655088	2.68294948	1.26044479	0.00425337	0.00549770	0.00225455	0.3249	0.1266	0.0365
	-4.47655088	2.96294427	0.08888350	0.00425337	0.00594084	0.00011902	0.0095	-0.0229	-0.0033
2435560.5	-4.63976002	2.45905373	1.18838272	0.00390933	0.00569403	0.00234728	-0.1446	0.1602	0.0488
	-4.63976002	2.72090426	0.09350626	0.00390933	0.00615786	0.00011206	0.0388	-0.0131	-0.0042
2435600.5	-4.78884548	2.22767228	1.07276390	0.00354727	0.00587193	0.00243235	-0.3617	0.1302	0.0342
	-4.78884548	2.47058144	0.09784436	0.00354727	0.00635491	0.00010478	-0.0676	0.0071	-0.0090
2435640.5	-4.92343330	1.98956928	0.97388843	0.00318565	0.00603107	0.00250959	-0.3639	-0.0091	-0.0302
	-4.92343330	2.21278188	0.10188618	0.00318565	0.00653165	0.00009725	0.0598	0.0311	-0.0056
2435680.5	-5.04319596	1.76543837	0.87210171	0.00280629	0.00617131	0.00257891	-0.3011	-0.1211	-0.0616
	-5.04319596	1.94832252	0.10562129	0.00280629	0.00668789	0.00008946	0.0429	0.0435	-0.0024
2435720.5	-5.14784827	1.49609861	0.76769240	0.00242531	0.00629248	0.00264021	-0.2075	-0.2089	-0.1100
	-5.14784827	1.67802651	0.10903989	0.00242531	0.00682345	0.00008143	0.0229	0.0522	-0.0037
2435760.5	-5.23714650	1.24229492	0.66099269	0.00203873	0.00639449	0.00269341	-0.0820	-0.1872	-0.1059

-5.23714650	1.40272382	0.112133340	0.00203875	0.006938200	0.00007320	0.0043	0.0420	-0.0043
2435800.5	-5.31388555	0.98479731	0.55232777	-0.00164753	-0.006567150	-0.00273845	-0.0438	-0.0894	-0.0492
	-5.31388555	1.12325028	0.11489337	-0.00164753	-0.00733195	0.00006479	0.0040	0.0230	-0.0018
2435840.5	-5.36890203	0.72438252	0.44226872	-0.00125279	-0.006584134	-0.00277521	-0.0152	0.0237	0.0038
	-5.36890203	0.86446947	0.11731360	-0.00125279	-0.00710455	0.00005619	0.0134	-0.0038	-0.0012
2435880.5	-5.41107595	0.46182979	0.33042140	-0.00085557	-0.006584034	-0.00203367	-0.0284	0.1617	0.0631
	-5.41107595	0.55516817	0.11938742	-0.00085557	-0.00715596	0.00004747	0.0084	-0.0312	-0.0014
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	-5.43732983	0.26825435	0.12111305	-0.00045696	-0.00718620	0.00003864	0.0262	-0.0398	0.0015
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	-5.44197059	-0.30709222	0.12348608	0.00034658	-0.00718342	0.00002071	0.0556	-0.0245	-0.0042
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2436080.5	-5.38300103	-0.85579767	-0.22553332	0.00113194	-0.006511800	-0.00282127	-0.1672	-0.0867	-0.0640
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	-5.32989383	-1.16130118	0.12434047	0.00152273	-0.00702223	-0.00000648	0.0104	0.0182	-0.0043
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2437600.5	3.28204697	-3.53234886	-1.59561543	0.00567904	-0.005366504	-0.00194830	-0.3270	-0.0462	-0.0402
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2437640.5	3.50312310	-3.33146366	-1.51483896	0.00537103	-0.005217557	-0.00204948	-0.0148	-0.0045	-0.0165
	3.50312310	-3.65913379	-0.06424253	0.00537103	-0.00558094	-0.00014269	-0.0611	-0.0033	-0.0030

2437640.52437640.5 HOLD YOUR HAT. TMAX HAS BEEN REACHED

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                                        ************    SUMMARY    ************
  GENERAL  IDENTIFICATI .  FOR  PLOD
PLOD II EPHEMERIS FIT  J BY TAPE TO SOURCE TAPE E9005, 40 DAY RESIDUALS
AND  4 DAY INTEGRAT     STEP, WRITTEN 6/23/64 BY CEVINE FOR   JUPITER
COORD TAPE IS E9    4RITTEN BY OROZCO BY PRE-EPHEM FROM CORRECTED DATA
WITH A  2 DAY '     SIZE, TAPE WRITTEN 4/28/64

RECORD  '    4                      14  BODY  NUMBER                          5
START                      2433280.50  MAX  DATE                    2437640.50
INT'     ICA  STEP  SIZE          '.00  RESIDUAL  STEP  SIZE              40.00
    .ERIS  STE   SIZE             40.00  NUMBER  CIFFS.                      8
 .ITIAL  PT.                          0  CIFF  CONVERGENCE       -0.999999999E-11
SIGSQ  TEST                C.499999999E-08  RMS  TEST                 0.399999999E-08
CD  =                      C.999999999E-08  SCOUT=                   0.
SCIN=                      0.999995 /9E-17  MEAN  MOTION  FLAG
COMPUTED  S GMA  IS        0.5578C859E-08


 //////////    NO  TAPES  WRITTEN    //////////


  PLANET  INVERSE  MASSES
  6000000.0000      408000.0000      32939C.0000          0.        3095350.0000
     1047.3550        3501.6000      22865.0000      19314.0000     3E0000.0000
  RADIUS  VECTOR  RESIDUAL  WEIGHT  FACTOR =  0.C9999999E 01  0.09999999E 01  C.09999999E 01
  OBLIQUITY  PSILON,  AND  SIN  ,COS  OF  IT
       4.0520619414299036-01
       9.1743695225096716-01
       3.9788118659275196-01
  ECLIPTIC  ELEMENTS
       5.2C26554205759239 00          1.45C2773936045E72-03          4.8910758649334887-02          2.2810079291C63422-02
       1.7446738198327909 00          4.7773850148970576 00          5.2796469381E62519 00
  ECLIPTIC  PCR  MATRIX
      .9.7134944901783260-01          2.3656338075068858-01         -2.2759538C61332172-02
      -2.3659164907701308-01          9.7160804703529102-01          1.4813923471370942-03
       2.2464182152272093-02          3.9458616386504C57-03          9.9973987512C62251-01
  EPOCH  PCSITION  AND  VELOCITY  EQUATORIAL
       3.3493566487720823 00         -3.4737659974601158 00         -1.5721612C25212809 00
       5.5856549787634442-03          4.9622486717934C72-03          1.9922660BC6C19393-03

 ****  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....     DELTA  X          DELTA  Y          DELTA  Z
MEAN  DEVIATION  ..................MD=SUM(DELTA)/N     -0.43083C92E-C8  -C.83651322E-C9  -'.17684114E-08
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N   0.32237586E-15   C.42768826E-15   0.77676991E-16
STANDARD  DEVIATION..............SD=SQRTF(SR-MD**2)   0.17430270E-C7   C.2066370CE-07   0.8634217?E-08
MAXIMUM  RESIDUAL  ..................................  0.39057183E-C7   C.525075C9E-C7   0.19116?58E-07
MINIMUM  RESIDUAL  ..................................  -0.41252767E-C7  -C.46466993E-C7  -0.20676C89E-07

****  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN ..... RADIUS VECTOR        CCSB  CL          DLAT=DB
MEAN  DEVIATION  ..................MD=SUM(DELTA)/N     -0.1534C494E-C8  C.43576701E-15  -0.28710547E-09
SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N   0.181126596-16   C.12876511E-16   0.125472C5E-18
STANDARD  DEVIATION..............SD=SQRTF.SR-MD**2)   0.39698C50E-C8   C.35884413E-C8   0.20746688E-09
MAXIMUM  RESIDUAL  ..................................  0.783576106-C8   C.10648755E-07   0.41677742E-09
MINIMUM  RESIDUAL  ..................................  -0.913473316-C8  -C.63784625E-08  -0.84141692E-09
```

APPENDIX III. PLOD II PROGRAM LISTINGS

```
PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 1

C
C
C    ************DIMENSION   STATEMENTS ***********************************
C
C
      DIMENSION CMAX(6),CMIN(6),PMAX(6),PMIN(6)
D     DIMENSION XDSA(1) ,RM(1)
D     DIMENSION  DELT(3)
D     DIMENSION YSTATS(3,3)
D     DIMENSION XTS(1),CTE(1)
D     DIMENSION DM(10),DMS(10),DTEMP(1)
D     DIMENSION CAR(1),AU(1),XLITE(1)
D     DIMENSION XSTATS(3,3)
D     DIMENSION YTIME(1)
D     DIMENSION ELM(7)
D     DIMENSION SQRTMU(1)
      DIMENSION INDUTA(6)
D     DIMENSION AK(1),AKS(1)
C
D     DIMENSION XL8(3),CMAT(3,3),WT(3)
D     DIMENSION PQRT(3,3),COSOB(1),SINOB(1)       ,XJDO(1)
D     DIMENSION  PP(3),PQ(3),PR(3)
D     DIMENSION ELEM(7),EPS1(1),DPXYZ(6) ,          XMU(1)
D     DIMENSION          FSTOP1(1),FSTOP2(1),STEST(1),SIG(1),ASOLVE(6)
     1    ,     EPSILN(1)
      DIMENSION PLANET(2),MWORD(22),NWORD(22),LWORD(22), KWORD(22)
     1        ,IWORD(22) ,NGIL(24)
D     DIMENSION DELTA(3),XNUM(1),SIGSQ(1) ,SL(1)    ,XMEAN(1)
D     DIMENSION AMAT(6,6),AMAT(16,6),BMAT(6)
D     DIMENSION TIME(1),XYZ(3),X1DOT(3),X2DOT(3),PQR(3,3),A(1),E(1),
     1XN(1),      SET(6,6)
D     DIMENSION                                          H(1) ,TMAX(1)
C     DIMENSION STATEMENTS (FROM DB)
D     DIMENSION DDATE (1)  , XJD(1)
D     DIMENSION VOLD(3)
D     DIMENSION XOLD(3)
C     DIMENSION FOR NEW COMMON
      DIMENSION DUMY1(2726),DUMY2(2246),Z2DL(1),Z2DM(1),Y2DL(1),Y2DM(1),
     1X2DL(1),Y2DM(1),ZDOTL(1),ZDOTM(1),YDOTL(1),YDOTM(1),XDOTL(1),
     2XDOTM(1),VZL(1),VZM(1),VYL(1),VYM(1),VXL(1),VXM(1),XJDL(1),
     3XJDM(1),HSL(1),HSM(1),DUMY3(5),ES(1),SZ(1),DTP(1),NOPT(1),NOD(1),

PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 2

     4 JOD(1),MOD(1),TS(2)
C
C
C    ********************END   DIMENSION  STATEMENTS  ************************
C
C
C                        ***  COMMON    STATEMENTS  ***
      COMMON DUMY1,DUMY2,Z2DL,Z2DM,Y2DL,Y2DM,X2DL,X2DM,ZDOTL,ZDOTM,
     1YDOTL,YDOTM,XDOTL,XDOTM,VZL,VZM,VYL,VYM,VXL,VXM,XJDL,XJDM,HSL,HSM,
     2DUMY3, ES,SZ,DTP,NOPT,NOD,JOD,MOD,TS
C                        ***          END    COMMON         ***
C
C
C                       READ  INPUT  AND  FORMAT  STATEMENTS
C
C    ********************************** **********************************
C    *                                                                    *
C    *  GROUP ONE INPUT DATA WILL INCLUDE PLANET TO BE INTEGRATED,        *
C    *  SOURCE TAPES FOR PLANET,WRITE TAPES SOURCE FOR PERTURBING BOD     *
C    *  IES,BCD RECORD FOR EPHEMERIS TAPE.                                *
C    *  GROUP TWO INPUT DATA WILL INCLUDE OPTIONS SUCH AS MEAN MOTION     *
C    *  WITH FLAG,PRINT OPTIONS,NO. OF ITERATIONS,AND CONTROL OPTIONS     *
C    *  GROUP THREE INPUT DATA WILL BE PROGRAM PARAMETERS FOR PLOD        *
C    *  AND FORTSZ,INCLUDING STEP SIZE (INTEGRATION,PRINT,TAPE,           *
C    *  NORMAL EQUATIONS,EPHEMERIS,ETC.),AND TOLERANCES FOR STPRG,        *
C    *  FOR CONVERGENCE,AND FORTSZ DIFF TABLE CONVERGENCE                 *
C    *  GROUP FOUR INCLUDES MAIN DATA DECK,WILL BE JULIAN DATE            *
C    *  FOLLOWED BY X,Y,Z,X,Y,Z,OR ELLIPTICAL ELEMENTS A,E,I,LONG         *
C    *  ASC.NODE,ARG.PER.,MEAN ANOM.,OTHERWISE DATA WILL BE READ          *
C    *  FROM TAPE                                                         *
C    *                                                                    *
C    ********** **********************************************************
C
C
C                           GROUP    ***    ONE
C
   40 CONTINUE
      WRITE OUTPUT TAPE 6,39
   39 FORMAT (1H1)
      READ INPUT TAPE 5,44,JEND,NBCD,,(PLANET(I),I=1,2)
   44 FORMAT(2I4,2A6)
      READ INPUT TAPE 5,41,MTAPE,MTAPO,MCHAN,KTAPE,KTAPO,KCHAN,
     1         LTAPE,LTAPO,LCHAN,KTAPE,KTAPO,KCHAN,ITAPE
```

```
PLOSMA          MAIN PROGRAM FOR PLOT CHARLES J. DEVINE                    7/01/64        PAGE 3

   41 FORMAT(4(13-A6,A3),I3)
C
      READ INPUT TAPE 5,112,(NWORD(I),I=1,22  ),(NWORD(I),I=1,22  ),
     1      (NWORD(I),I=1,22  ),(NWORD(I),I=1,22),(NWORD(I),I=1,22)
  112 FORMAT(12A6/10A6)
C
C                          END   GROUP  ONE
C
C*************************  ***************************************************
C
C                          GROUP    ***    TWO
C
   45 CONTINUE
      READ INPUT TAPE 5,46,KAR,LAP,KAM,PAP,JAR,K,NCBCD,
     1        KPCS,PEAN      ,ITRPAY,NEPOCH,NCOF,NECLPT,KAN
C
   46 FORMAT(14I4)
C                          END   GROUP    TWO
C
C*****************************************************************************
C
C                          GROUP    ***    THREE
C
   47 CONTINUE
C     PARAMETERS FOR FORTS2,INCLUDES STEP SIZE,DIFF TABLE CONV.,ETC.
      READ INPUT TAPE 5,48,ME ,JD ,ND ,NFT ,IL ,M,FS
   48 FORMAT(5I4,F12.6,E17.8)
C     FCO,JOD,NJC,NCPT,ARE 817 IN FORTRAN,SO ARE SHIFTED TO 835 IN FORDV
C           FOR FORTS2
   49 CONTINUE
C     PARAMETERS FOR PLOT,AND PLOT SUBA'S.,CONV.,TOLERANCE,STPRG.,ETC.
      READ INPUT TAPE 5,50,MMAX,MMAX,MPRINT,NPRINT,KPRINT,NSTEP,KEPHP,  PRINTOPT
     1                 ,MEARTH,PTEST,NREL   ,
     2         STEST-EPSILN,CD,SCCJT,SCIN,CEPSIL,
     3         FSTOP1,FSTOP2                                            STEP OPT
C
   50  FORMAT(10I3/4E17.8/2E17.8,2F12.6)
C
C                    END  GROUP  THREE
C
C*****************************************************************************
C
```

```
PLOSMA          MAIN PROGRAM FOR PLOT CHARLES J. DEVINE                    7/01/64        PAGE 4

      CALL OPINPT(NT,3)
      WRITE OUTPUT TAPE 6,2017
 2017 FORMAT(1H0,  15H WEIGHT  FACTOR// )
      CALL OUTPT(NT,3,3)
      CALL OPINPT(CAB,1,  AU,1  )
D     XLITE=(CAL*8440.)/AU
      CALL OPINPT(XTS,1,XTE,1,DM,1G,FM,1,XPEAN,1)
D     TWOPI=3.141592653589793  *2.0
D     XXJ=2433282.423
C     CALL OBLIQ HERE FOR EPSILON
      CALL OBLIQ(XXJ,E-S))
D     EPSL=EPSI*TWOPI
D     CCSOB=COSF(EPSL)
D     SINOB=SINF(EPSL)
C
      DO 120 I=1,6
      UMAX(I)=-1.0E+38
  120 UMIN(I)=1.0E+38
      NRECRD=14
      XT=2
      KT1=1
      XCONTR=1.0
D     XDIA=0.0
      XBODY=1.0
      XNBODY=NBODY
      NWRITE=2
D     RESO=0.0
      ITERAX=0
      KRY=1
      MAFLAG=2
      GO TO (21,22,23),MAR
 21   CONTINUE
      WRITE OUTPUT TAPE 6,67,NTAPO,NCHAN
   67 FORMAT(14H    LOAD  TAPE,A6,15H    ON  CHAN.  ,A3///)
      PRINT 67,NTAPO,NCHAN
      PAUSE 77777
      CALL SONH (NTAPE)
      REWIND NTAPE
      GO TO 24
 22   CONTINUE
      WRITE OUTPUT TAPE 6,67,NTAPO,NCHAN
      PRINT 67,NTAPO,NCHAN
```

```
PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 5

      P.USE 77777
      CALL SDMM (MTAPE)
      REWIND MTAPE
      GO TO 24
 23   CONTINUE
      WRITE OUTPUT TAPE 6,728,MTAPC,MCHAN,MTAPO,MCHAN
      PRINT 728,MTAPC,MCHAN,MTAPO,MCHAN
      PAUSE 77777
      CALL SDMM (MTAPE)
      CALL SDMM (MTAPE)
      REWIND MTAPE
      REWIND MTAPE
 24   CONTINUE
      GO TO (25,26,27,29),MSTEP
 25   CONTINUE
      READ TAPE MTAPE,XM1
      READ TAPE MTAPE,XM2
C     XM=XM2-XM1
      GO TO 29
 26   CONTINUE
  135 FORMAT(34H  BCD  FROM  SOURCE  TAPE  HEADING//(1X,12A6 ))
      READ TAPE MTAPE,NGIL
      WRITE OUTPUT TAPE 6,135,NGIL
      PRINT 135,(NGIL  (I),I=1,24)
      READ TAPE MTAPE,NBCDWD
      GO TO 29
 27   CONTINUE
      READ TAPE MTAPE,NGIL
      WRITE OUTPUT TAPE 6,135,NGIL
      PRINT 135,(NGIL  (I),I=1,24)
      READ TAPE MTAPE,NBCDWD
      READ TAPE MTAPE,XM1
      READ TAPE MTAPE,XM2
C     XM=XM2-XM1
 29   CONTINUE
C
C*****************************************************************************
C
C
C                              GROUP    ***    FOUR
C
C*****************************************************************************
```

```
PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 4

C
C     COMPUTE MASS OF PLANETS,FOR TRANSFER TO DERIV,AND OTHERS.
  119 CONTINUE
      NPLAN=NBODY
C
C
C
C
      DO 117  I=1,10
C     IF(DMS(I))333,332,333
C 333 DMS(I)=1.0/CM(I)
      GO TO 117
C 332 DMS(I)=0.0
  117 CONTINUE
C
      IF(4-NPLAN)209,207,211
  207 GO TO (208,209),NEARTH
  208 GO TO 211
  209 NPLAN=NPLAN+1
  211 CONTINUE
C
C     AM=0.017202098950000
C     AMS=AM*AM
C     XMU=AMS*(1.+DMS(NPLAN)     + RM)
C     SQRTMU=SQRTF(XMU)
C
C     DMS(4)=0.0
C     DMS(NPLAN)=0.0
C     THIS IS OPTION FOR TEST RUN WITH ALL PERTURBING MASSES ZERO
      GO TO (214,216),MTEST
  214 CONTINUE
      DO 215 I=1,10
C 215 DMS(I)=0.0
  216 CONTINUE
C
      WRITE OUTPUT TAPE 6,11
      CALL DOUTPT(DMS,10,10)
   11 FORMAT(1H0, 61H COMPUTED  MASSES  WITH  MAIN  BODY  AND EARTH  SET
     1  TO  ZERO//)
C
  118 CONTINUE
C
```

```
 PLODMA          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 7

      GO TO (55,65,70),NEPOCH
   55 CONTINUE
C     HERE XJD,TMAX,XYZ,ZDOT,YDOT,ZDOT ARE READ IN AT EPOCH
C
      CALL OPINPT(XJC,1,TMAX,1,XOLD,3,VOLD,3)
D     XJDO=XJD
      GO TO 4                                                        START
C
C*****************************************************************************
C
   60 CONTINUE
C
C     HERE XJD,TMAX,A,E,I,LONG ASC,ARG PER,MEAN ANOM ARE READ IN
C
      CALL OPINPT(XJC,1,TMAX,1,ELEM,7)
D     XJDO=XJD
C     NOTE ELEM(2) WILL BE READ OR COMPUTED. IF COMPUTED SET TO ZERO
      GO TO (61,62),MEAN
   61 CONTINUE
C     GO TO WHERE XMU IS COMPUTED, AND RETURN
      MAFLAG=1
   75 CONTINUE
C
C     ELEM(2)=(1./ELEM(1))*SQRTF(XMU/ELEM(1))
      GO TO 63
C
   62 CONTINUE
C     ELEM(2)=XMEAN
C     ELEM(1)=(XMU/ELEM(2)**2)**(1./3.)
C
   63 CONTINUE
      MAFLAG=3
C     A= ELEM(1)
C     XN= ELEM(2)
C     E= ELEM(3)
C     FORM PQR MATRIX FOR TRANSX
C
C     SINP=SINF(ELEM(6))
C     COSP=COSF(ELEM(6))
C     SINL=SINF(ELEM(5))
C     COSL=COSF(ELEM(5))
C     SINI=SINF(ELEM(4))
```

```
 PLODMA          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 8

C     COSI=COSF(ELEM(4))
C
      GO TO (1302,1301),NECLPT
C
C
C     HERE ELEMENTS WILL BE TRANS FROM EQUATORIAL TO ECLIPTIC
 1301 CONTINUE
C     CASE ONE,SOLVE FOR LONG ASNODE,INCLINATION
C
C     SX=SINI*SINL
C     SY=-SINOB*COSI+COSOB*SINI*COSL
C     SZ=COSOB*COSI+SINOB*SINI*COSL
C
C
C     CALL SPHER(SX,SY,SZ,RHOG,XLN,XLAT)
C
C     HAPPI=3.14159265358979324/2.
C     ELEM(5)=HAPPI-XLN
C     ELEM(4)=HAPPI-XLAT
C
C     CASE TWO SOLVE FOR PERIHELION,INCLINATION
C
C     SX=SINOB*SINL
C     SY=COSOB*SINI-SINOB*COSI*COSL
C     SZ=COSOB*COSI+SINOB*SINI*COSL
C
C     CALL SPHER(SX,SY,SZ,RHOG,XLN,XLAT)
C
C     OMEGA=HAPPI-XLN
C     ELEM(6)=ELEM(6)-OMEGA
C     CHECK=HAPPI-XLAT
      WRITE OUTPUT TAPE 6,1303
 1303 FORMAT(1H0,40H  ELEMENTS  ROTATED  INCLUDING  I  CHECK//)
      CALL DOUTPT(ELEM,7,7,CHECK,1,1)
C
C     NOW COMPUTE NEW SINP,SINL,SINI,AND COS
C     SINP=SINF(ELEM(6))                                         PERIHEL
C     COSP=COSF(ELEM(6))                                         PERIHEL
C     SINL=SINF(ELEM(5))                                         LONGASN
C     COSL=COSF(ELEM(5))                                         LONGASN
C     SINI=SINF(ELEM(4))                                         INCLINAT
C     COSI=COSF(ELEM(4))                                         INCLINAT
```

```
 PLOOMN          MAIN PROGRAM FOR PLCO CHARLES J. DEVINE                    7/01/64        PAGE 9

C     HERE ELEMENTS HAVE BEEN READ IN ECLIPTIC,ONLY COMPUTE PQR
 1302 CONTINUE
C     COMPUTE PQR
C
D     PQR(1,1)=COSP*COSL-SINP*SINL*COSI                                  PX
D     PQR(2,1)=-SINP*COSL-COSP*SINL*COSI                                 QX
D     PQR(3,1)=SINL*SINI                                                 RX
D     PQR(1,2)=COSP*SINL+SINP*COSL*COSI                                  PY
D     PQR(2,2)=-SINP*SINL+COSP*COSL*COSI                                 QY
D     PQR(3,2)=-COSL*SINI                                                RY
D     PQR(1,3)=SINP*SINI                                                 PZ
D     PQR(2,3)=COSP*SINI                                                 QZ
D     PQR(3,3)=COSI                                                      RZ
C
C
C     NOW CALL TRANSX TO GO TO XYZ,XDOT,YDOT,ZDOT
C
C*******************************************************************************
C
C     THIS WILL ALSO BE MAIN PROGRAM RETURN POINT
C
C                                                                        *******
C                                                          MAIN LOOP POINT*******
C                                                                        *******
   65 CONTINUE
      DO 524 I=1,3
      UMAX(I)=-1.0E+38
      UMAX(I+3)=-1.0E+38
      UMIN(I)=1.0E+38
      UMIN(I+3)=1.0E+38
      DO 524 J=1,3
D     YSTATS(I,J)=0.0
D 524 XSTATS(I,J)=0.0
D     XAM=0.0
      CALL TRANSX (PQR,DMXYZ,ELEM,XML)
      DO 66 I=1,3
D     XOLD(I)=DMXYZ(I)
D  66 VOLD(I)=DMXYZ(I+3)
      WRITE OUTPUT TAPE 6,1304
 1304 FORMAT(1H0,90H  ECLIPTIC  POS-VEL  FROM  TRANSX AND EQUATORIAL  PO
     1S-VEL  AFTER  ROTATION  FROM  ECLIPTIC//)
      CALL DOUTPT (XOLD,3,3,VOLD,3,3)
```

```
 PLOOMN          MAIN PROGRAM FOR PLCO CHARLES J. DEVINE                    7/01/64        PAGE 10

C     AFTER TRANSX,ONLY ROTATE XYZ,NOW+2
      NPOT=4
C     HERE SET UP TRANS FROM EQUA TO ECLIPTIC
      SINO=-SINOB
      CALL STUMPS (XOLD,VOLD,DELTA,XLB,CMAT,       COSOB,SINO ,NPOT)
      CALL DOUTPT(XOLD,3,3,VOLD,3,3)
C     NOW XOLD,VOLD,ARE IN EQUATORIAL
      GO TO 4
C
C*******************************************************************************
C
   70  CONTINUE
C
C             HERE READ TAPE AT EPOCH FOR INITIAL VALUES
C             NTAPE=15 READ TAPE NTAPE THIS IS THIRD INPUT CHOICE
C
      CALL DPINPT (XJC,1,TMAX,1  )
D     XJCO=XJD
    3 READ TAPE NTAPE,CDATE(1),CDATE(2),(XOLD(M),XOLD(M+3),M=1,3),
     1          (VOLD(M),VOLD(M+3),M=1,3)
D     IF(CDATE-XJD)3,2,5
    5 WRITE OUTPUT TAPE 6,8,CDATE
      PRINT 8,CDATE
    8 FORMAT(1H0,28H  SOURCE  TAPE  STARTS  AT  F10.1,22H  INTEGRATION
     1STOPPED/80H   OPERATOR  REMOVE  TAPES  , WAIT  TO  SEE  IF  PROGRA
     1M  CALLS  FOR  NEW  TAPES//)
      GO TO 1077
   2  CONTINUE
      BACKSPACE NTAPE
    4 CONTINUE
      GO TO (1002,1003),KRY
 1002 CONTINUE
      KRY=2
C
C*******************************************************************************
C
C                        IDENTIFICATION
C
      WRITE OUTPUT TAPE 6,543,DEPSIL,XMEAN,MEAN,KAM,LAM,KAN,MAM,NSTEP,
     1                        NPRINT,JAM,NEPHM,MTEST,ITRMAX,NEPOCH,
     2                        NECLPT,NREL,JEND
  543 FORMAT(2X///
```

```
PLOOMN          MAIN PROGRAM FOR PLCO CHARLES J. CEVINE                  7/01/64        PAGE 11

     9       26H  DEPSIL                  ,E16.8/26H  MEAN  MOTION  INPU
     1T     ,L18.8/26H  MEAN                    ,I4/26H  KAM
     2         ,I4/26H  LAM                     ,I4/26H  MAN
     3         ,I4/26H  MAM                     ,I4/26H  NSTEP
     4         ,I4/26H  NPRINT                  ,I4/26H  JAM
     5         ,I4/26H  NEPHM                   ,I4/26H  MTEST
     6         ,I4/26H  ITRMAX                  ,I4/26H  NEPOCH
     7         ,I4/26H  NECLPT                  ,I4/26H  NREL
     8         ,I4/26H  JENS                    ,I4/////)
C
C     CC WE WRITE A RESIDUAL TAPE FOR (N-1) INTEGRATIONS
C
      GO TO (109,110),MPRINT
  109 CALL SUMP(ITAPE)
      REWIND ITAPE
      UCON=4.0
      WRITE TAPE ITAPE,(IWCRD(I),I=1,22),(PLANET(I),I=1,2)
      WRITE TAPE ITAPE,XBODY,UCON,XJDD,TMAX,FSTOP2,XNBODY,FSTOP2
      KI2=KTAPE
      KI3=NPRINT
      KI4=KAM
      KTAPE=ITAPE
      NPRINT=3
      KAM=2
      NWRITE=1
      WRITE OUTPUT TAPE 6,3004,(IWCRD(I),I=1,22),(PLANET(I),I=1,2),
     1    XBODY,UCON  ,XJDD,TMAX,FSTOP2,XNBODY,FSTOP2
  110 CONTINUE
C
C
C     EPOCH OPTIONS AND REPRINT OF EPOCH DATA,PLUS MEAN OPTION
C
C*****************************************************************************
C
      GO TO (1008,1010,1012),NEPOCH
C
 1008 CONTINUE                                                          OPINPT
      WRITE OUTPUT TAPE 6,1015
 1015 FORMAT(1H0,56H  INPUT  DATA  IS  BY  CARDS  IN  DOUBLE -PRECISION
     1 CEC///)
      CALL DOUTPT(XOLD,3,3,VOLD,3,3)
      GO TO 1030
```

```
PLOOMN          MAIN PROGRAM FOR PLCO CHARLES J. CEVINE                  7/01/64        PAGE 12

C
C*****************************************************************************
C
 1010 CONTINUE                                                         ELLIPT
      WRITE OUTPUT TAPE 6,1017                                         OPINPT
 1017 FORMAT(1H0,46H  INPUT  DATA  IS  BY  CARDS  D.P.  ELLIPTICAL///)
      CALL DOUTPT(ELEM,7,7)
      WRITE OUTPUT TAPE 6,1018
 1018 FORMAT(1H0,13H  FOR  MATRIX///)
      DO 1019 I=1,3
0     PP(I)=PQR(1,I)
P     PQ(I)=PQR(2,I)
01019 PR(I)=PQR(3,I)
      CALL DOUTPT(PP,3,3,PQ,3,3,PR,3,3)
C
      WRITE OUTPUT TAPE 6,1021
 1021 FORMAT(1H0,36H  TRANSFORMATION  CHECK  XYZ  XY2DOT///)
      CALL DOUTPT(DPXYZ,6,6                )
      GO TO 1030
C
C*****************************************************************************
C
 1012 CONTINUE                                                          TAP
      WRITE OUTPUT TAPE 6,1023
 1023 FORMAT(1H0,40H  INPUT  DATA  FROM  SOURCE  TAPE  EPOCH///)
      CALL DOUTPT(XOLD,3,3,VOLD,3,3)
C
 1030 CONTINUE
      WRITE OUTPUT TAPE 6,1016
 1016 FORMAT(1H0,22H  END  OF  INPUT  DATA////)
      GO TO (1032,1034),MEAN
 1032 WRITE OUTPUT TAPE 6,1025
 1025 FORMAT(1H0,23H  MEAN  MOTION  IS  COMPUTED///)
      GO TO 1003
 1034 WRITE OUTPUT TAPE 6,1026,XMEAN
 1026 FORMAT(1H0,37H  MEAN  MOTION  IS  HELD  FIXED  AT  E16.8///)
      GO TO 1003
 1003 CONTINUE
      WRITE OUTPUT TAPE 6,1027
 1027 FORMAT(1H0,18H  BEGIN  ITERATION///)
 1040 CONTINUE
      WRITE OUTPUT TAPE 6,1041,XJDD
```

```
 PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                    7/01/64        PAGE 13

 1041 FORMAT(1HO,29H  EPOCH  VALUES  EQUATORIAL  F12.2///)
      CALL DOUTPT(XOLD,3,3,VOLD,3,3)
C
C*****************************************************************************
C
    7 CONTINUE
      XSM=X(1)
      XSL=X(2)
      XJCM=XJD(1)
      XJCL=XJD(2)
      VXM=VOLD(1)
      VXL=XOLD(4)
      VYM=V.LD(2)
      VYL=XOLD(5)
      VZM=XOLD(3)
      VZL=XOLD(6)
      XCCTM=VOLD(1)
      XCCTL=VOLD(4)
      YCCTM=VOLD(2)
      YCCTL=VOLD(5)
      ZCCTM=VOLD(3)
      ZCCTL=VOLD(6)
C
C*****************************************************************************
C     SUBR TO COMPUTE PQR MATRIX AND TRANSFORM XYZ TO ELIPTIC
      DO 6 I=1,3
D     CPXYZ(I)=XOLD(I)
D  6  CPXYZ(I+3)=VOLD(I)
D     SI OB= 0.0
D     CO OB= 1.0
      CALL ELEMTS   (CO OB,SI OB,CPXYZ,XMU   ,PQRT,ELM,MEAN,XMEAN)
      WRITE OUTPUT TAPE 6,2004
 2004 FORMAT(1HO,37H  ELLMENTS  CHECK  FROM  SUBR  ELEMTS///  )
      CALL DOUTPT (ELM,7,7)
      WRITE OUTPUT TAPE 6,2005
 2005 FORMAT(1HO,33H  TRANSPOSE  PQR  MATRIX  CHECK  ///)
      DO 1120 I=1,3
D     PP(I)=PQRT(I,1)
D     PQ(I)=PQRT(I,2)
D1120 PR(I)=PQRT(I,3)
      CALL DOUTPT(PP,3,3,PQ,3,3,PR,3,3)                          ECLIPTIC
 2014 CONTINUE



 PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                    7/01/64        PAGE 14

      CALL ELEMTS   (COSOB,SINOB,CPXYZ,XMU   ,PQRT,ELM,MEAN,XMEAN)
      WRITE OUTPUT TAPE 6,1100
 1100 FORMAT(1HO, 20H  ECLIPTIC  ELEMENTS//  )
      CALL DOUTPT (ELM,7,7)
      WRITE OUTPUT TAPE 6,1101
 1101 FORMAT (1HO,23H  ECLIPTIC  PQR  MATRIX//   )
      DO 2020 I=1,3
D     PP(I)=PQRT(I,1)
D     PQ(I)=PQRT(I,2)
D2020 PR(I)=PQRT(I,3)
      CALL DOUTPT(PP,3,3,PQ,3,3,PR,3,3)
      GO TO (75,2008,9011),MNFLAG
 2008 CONTINUE
      DO 122 I=1,3
      DO 122 J=1,3
D 122 PQR(J,I)=PQRT(I,J)
      DO 2011 I=1,7
D2011 ELEM(I)=ELM(I)
D     A=ELEM(1)
D     AN=ELEM(2)
D     E=ELEM(3)
      CALL TRANSX (PQR,CPXYZ,ELEM,XMU)
      DO 1350 I=1,3
D     XOLD(I)=CPXYZ(I)
D1350 VOLD(I)=CPXYZ(I+3)
      WRITE OUTPUT TAPE 6,1305,XJCC
 1305 FORMAT(1HO,28H  ECLIPTIC  EPOCH  POS-VEL  ,F12.1//)
      CALL DOUTPT (XOLD,3,3,VOLD,3,3)
C     AFTER TRANSX,ONLY ROTATE XYZ,NROT=2
      NROT=2
C     HERE SET UP TRANS FROM EQUA TO ECLIPTIC
D     SINO=-SINOB
      CALL STINKS (XOLD,VOLD,DELTA,XL8,CMAT,       CCSOB,SINO ,NROT)
C     NOW XOLD,VOLD, ARE IN EQUATORIAL
      X  =XOLD(1)
      VXL=XOLD(4)
      VYM=XOLD(2)
      VYL=XOLD(5)
      VZM=XOLD(3)
      VZL=XOLD(6)
      XCCTM=VOLD(1)
      XCCTL=VOLD(4)
```

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PLOGMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 15

      YDOTM=VOLD(2)
      YDOTL=VOLD(5)
      ZDOTM=VOLD(3)
      ZDOTL=VOLD(6)
      WRITE OUTPUT TAPE 6,1241,XJDO
      CALL DOUTPT(XOLD,3,3,VOLD,3,3)
  901 CONTINUE
      WRITE OUTPUT TAPE 6,51
   51 FORMAT(1H1,48H  EPHEMERIS  FORMAT  FOR  EACH  JULIAN  DATE  IS//
     *12CH  JUL-DATE   EQUA. X    EQUA. Y    EQUA. Z   EQUA XDOT  EQUA Y
     *DOT  EQUA ZDOT          7PF0X          7PF0Y          7PF0Z   /
     *12CH              ECLP. X    ECLP. Y    ECLP. Z   ECLP XDOT  ECLP Y
     *DOT  ECLP ZDOT          7PF0P          7PF0SB0L       7PF0B   // )
C*****************************************************************************
C
C     *** CALL FAP FORDV TO LOAD AND OPERATE FLR7SZ
C
      XDO=PO
      JDO=JD
      NDO=ND
      NOPT=NPT
      IFL=IL
C
C     SET UP IFLAG ADDRESS AND SET IFL=6,SET XJD=TS
      TS(2)=XJD(1)
      TS(1)=XJD(2)
C
  902 CALL FORDV(IFLAG,IFL,TS(2))
  903 GO TO (200,300,400,500,600),IFLAG
C     SUBROUTINE CALL STATEMENTS FOR DER,TSTOP,ECS,ERR
C
C     SUBR DERIV COMPUTES ACCELERATION AND STORES IN COMMON 65736-12
  200 CALL DERIV(NTAPE,NOBOD,KPOS,      XTS,XTE,DPS,'LITE,XMU,AKS,NAM,
     *                NREL,XDSA,XH)
      CALL SPOT
C     TSTOP  W.C.T. T,X,Y,Z,XD,YD,ZD,AND INCREMENTS TSTOP
  300 CALL TSTOP        (      NTAPE,LTAPE,KTAPE,          DELTA,YTIME,
     1               DELT,COSOB,SINOB,CMAT,XLB, XJDO   ,XYZ,XIDOT,
     1                 KAM,LAM,KAN,NWRITE,NPRINT
C     MAIN PROGRAM STATISTIC COMPUTATION
C     XNM=XNM+1.0
      DO 525 I=1,3
```

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PLOGMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 16

      FMAX(I   )=MAX1F(UMAX(I   ),DELTA(I))
      FMAX(I+3)=MAX1F(UMAX(I+3),DELT (I))
      FMIN(I   )=MIN1F(UMIN(I   ),DELTA(I))
      FMIN(I+3)=MIN1F(UMIN(I+3),DELT (I))
      UMAX(I)=FMAX(I)
      UMAX(I+3)=FMAX(I+3)
      UMIN(I)=FMIN(I)
      UMIN(I+3)=FMIN(I+3)
C     XSTATS(I,1)=XSTATS(I,1)+DELTA(I)
C     YSTATS(I,1)=YSTATS(I,1)+DELT (I)
C     YSTATS(I,2)=YSTATS(I,2)+(DELT (I)**2)
C 525 XSTATS(I,2)=XSTATS(I,2)+(DELTA(I)**2)
C     FLAG FOR TSTOP  INCR. FOR WRITING EPHM.
      IF(NEPHM) 303,303,402
C
  302 CONTINUE
C     XJD=XJD+FSTOP2
      TS(1)=XJD(2)
      TS(2)=XJD(1)
      CALL SPOT
  303 CONTINUE
      CALL SET32(POR,XYZ,XIDOT,A,E,XN,SET,YTIME,CMAT)
      CALL SETUP2(SET,DELT ,XNUM,SIGSQ,AMAT,BMAT,MMAX,NMAX,
     1           NGOSGL,STEST,WT)
      GO TO(380,402,402),NGOSGL
  380 CONTINUE
C     XJD=XJD+FSTOP
      TS(1)=XJD(2)
      TS(2)=XJD(1)
      CALL SPOT
C     ECSER TESTS FOR XJD MAX, T LESS MAX RETURN, T GREATER MAX OUT
C     TMAX IS READ IN AT DESIRED CUT OFF TIME
  400 CALL ECSER(TMAX,JIM)
      GO TO (402,403,405),JIM
  402 CONTINUE
      GO TO (4021,600),JAM
 4021 CONTINUE
C     SL=SIGSQ
      ATA=XNUM
      MTA=XNUM
      NCHUK=NMAX
      DO 391 I=1,6
```

```
 PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 17

      DO 390 J=1,6
D 390 AMATT(I,J)=AMAT(I,J)
D 391 XSOLVE(I)=BMAT(I)
      GO TO (83,82),MEAN
D  82 AMATT(5,5)=0.0
   83 CONTINUE
      CALL STPRG2(AMATT,XSOLVE,SL,NCHOR,MTA,SDIN,SDOUT,CD ,
     *NINA,INOUTA,KPRINT)
      GO TO 700
  403 CALL SPOT
  405 CONTINUE
C
  500 CALL ERRSR
  501 GO TO 600
C
C
C*******************************************************************************
C
  700 CONTINUE
C     WILL BE INSTRUCTIONS TO COMPUTE CORRECTIONS
C     SUBROUTINE TO COMPUTE CORRECTIONS
      CALL CORECT(XSOLVE,MEAN,XMEAN,ELEM,PQR,XPO        )
C
C     IF RESIDUAL TAPE WRITTEN ON (N-1) INTEGRATIONS BRANCH HERE
      GO TO (113,114),MPRINT
  113 END FILE ITAPE
  114 CONTINUE
C
      GO TO (1200,1201,1202,,204),NSTEP
 1200 CONTINUE
      REWIND MTAPE
      GO TO 1203
 1201 CONTINUE
      REWIND NTAPE
      READ TAPE MTAPE,NBCDWD
      READ TAPE NTAPE,NBCDWD
      GO TO 1203
 1202 CONTINUE
      REWIND MTAPE
      REWIND NTAPE
      READ TAPE NTAPE,NBCDWD
      READ TAPE NTAPE,NBCDWD
```

```
 PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                  7/01/64        PAGE 18

      GO TO 1203
 1204 CONTINUE
      REWIND MTAPE
      REWIND NTAPE
 1203 CONTINUE
      ITERAX=ITERAX+1
      DO 526 I=1,3
      DO 523 J=1,2
D     YSTATS(I,J)=YSTATS(I,J)/XNM
D523  XSTATS(I,J)=XSTATS(I,J)/XNM
D     YSTATS(I,3)=SQRTF(YSTATS(I,2)-(YSTATS(I,1)**2))
D526  XSTATS(I,3)=SQRTF(XSTATS(I,2)-(XSTATS(I,1)**2))
C     THIS IS STPRG2 CONVERGENCE TEST,REGULATE BY SDOUT, SDIN
D     XSUMO=0.0
      DO 430 I=1,6
D 430 XSUMO=XSUMO+XSOLVE(I)
C     IF(XSUMO)433,432,433
  432 CONTINUE
      WRITE OUTPUT TAPE 6,434
  434 FORMAT(24H  CONVERGENCE  BY STEPRG//)
      IF(ITERAX-2)433,720,720
  433 CONTINUE
D     SIGSQN=SIGSQ/XNUM
D     SIG=SQRTF(SIGSQN)
D     IF(SIG-EPSILN)720,720,715
  715 CONTINUE
C     THIS IS MOD TEST
D     RMS1=SIG
D     SMALL=ABSF(RMS1-RMSO)
D     IF(SMALL-DEPSIL)716,716,717
  716 CONTINUE
      WRITE OUTPUT TAPE 6,718,RMS1,RMSO
  718 FORMAT(1H0, 28H RMS  DIFFERENCE  NEGLIGIBLE/
     1          11H  RMS(I+1)=E16.8/11H  RMS(I)  =E16.8///)
      GO TO 720
  717 CONTINUE
D     RMSO=RMS1
      IF(ITRMAX-ITERAX)720, 84,750
   84 NT1=2
      NPRINT=.
  750 CONTINUE
      PRINT 544,SIG ,XJO
```

```
PLOOMN          MAIN PROGRAM FOR PLOO CHARLES J. DEVINE                  7/01/64        PAGE 19

 544  FORMAT(1H0,4H  SIGMA  ,E16.8,21H  FOR  JULIAN  DATE ,F12.2///)
D     ELAPST=XJD-XJDO
      WRITE OUTPUT TAPE 6,760,XJD,ELAPST,XNUM,SIG,SIGSQ,VXM,VYM,VZM
  760 FORMAT (1H0,20X,45H  ********************************************//
     146H          PLOO  HAS  EXCEEDED  TOLERANCES  ,IT  WILL  NOW  CORR
     2ECT//55H                EPOCH  VALUES  AND  BEGIN  A  NEW  ITERATION.///
     342H          JULIAN  DATE.....,F12.2//
     442H          ELAPSED  TIME  IN  DAYS.....,F12.2//
     542H          NUMBER  OF  INTEGRATION  STEPS..,F12.0//
     642H          SIGMA.....,E16.8//
     742H          SIGMA  SQUARE  X  V.....,E16.8//
     814H          X  =F16.8,6H  Y  =F16.8,6H  Z  =F16.8////)
      GO TO (86,87),NT1
   87 WRITE OUTPUT TAPE 6-85
   85 FORMAT(1H0,100H  PLOO  HAS  EXCEEDED  MAX  ALLOWED  ITERATIONS  WI
     *THOUT  CONVERGENCE  AND  THATS  THE  END  WROTHER//)
      GO TO 600
   86 CONTINUE
C     BACK IN MAIN, PLACE AFTER SIG TEST, JUST BEFORE COPR.
      DO 711 I=1,6
      DO 710 J=1,6
D 710 AMAT(I,J)=0.0
D 711 HMAT(I)  =0.0
D     SIGSQ=0.0
D     XNUM=0.0
D     XJD=XJDO
      KNFLAG=3
C     INCLUDE ALL COUNTERS ABOVE
C 750 GO TO TRANSFORMATION SUBROUTINE AND START OVER
      WRITE OUTPUT TAPE 6,528,((XSTATS(I,J),I=1,3),J=1,3)
     1                ,(FMAX(I),I=1,3),(FMIN(I),I=1,3)
      WRITE OUTPUT TAPE 6,529,(( YSTATS(3,J),(YSTATS(I,J),I=1,2)),J=1,3)
     1,FMAX(6),(FMAX(I),I=4,5),FMIN(6),(FMIN(I),I=4,5)
      GO TO 65
C
C     WRITE OUT ALL WANTED QUANTITS
  720 CONTINUE
      NT=2
      GO TO (115,116),NPRINT
  115 CONTINUE
      KTAPE=K12
      NPRINT=K13
```

```
PLOOMN          MAIN PROGRAM FOR PLOO CHARLES J. DEVINE                  7/01/64        PAGE 20

      KA=K14
      CALL RUN(ITAPE)
  116 CONTINUE
      GO TO (725,726,727,730),NPRINT
  725 CONTINUE
C
C*************************************************************************
C
      WRITE OUTPUT TAPE 6,728,LTAPC,LCHAN,KTAPC,KCHAN
      PRINT 728,LTAPC,LCHAN,KTAPO,KCHAN
      NT=1
  728 FORMAT(1H0,A6,12H    ON  CHAN,A3/A7,12H    ON  CHAN,A3// )
      PAUSE 77777
      CALL SDNF (LTAPE)
      CALL SDNF (KTAPE)
      REWIND LTAPE
      REWIND KTAPE
C     HEADING FOR BOTH KTAPE,LTAPE
      WRITE TAPE LTAPE,(LWORD(I),I=1,22  ) (PLANET(I),I=1,2)
      WRITE TAPE KTAPE,(KWORD(I),I=1,22  ),(PLANET(I),I=1,2)
      WRITE TAPE LTAPE,XBODY,XCONTR,XJDO,TMAX,FSTOP2,XNBODY,FSTOP2
      WRITE TAPE KTAPE,XBODY,XCONTR,XJDO,TMAX,FSTOP2,XNBODY,FSTOP2
      WRITE OUTPUT TAPE 6,740,NRECRD ,NBODY,XJDO,TMAX,
     1          FSTOP2,(LWORD(I),I=1,22  ),(PLANET(I),I=1,2)
      WRITE OUTPUT TAPE 6,740,NRECRD ,NBODY,XJDO,TMAX,
     1          FSTOP2,(KWORD(I),I=1,22  ),(PLANET(I),I=1,2)
      GO TO 730
C
C*************************************************************************
C
  726 CONTINUE
      WRITE OUTPUT TAPE 6,67,LTAPO,LCHAN
      PRINT 67,LTAPO,LCHAN
      PAUSE 77777
      CALL SDNF (LTAPE)
      REWIND LTAPE
C     BCD HEADING FOR EPHEMERIS TAPE
      WRITE TAPE LTAPE,(LWORC(I),I=1,22  ),(PLANET(I),I=1,2)
      WRITE TAPE LTAPE,XBODY,XCONTR,XJDO,TMAX,FSTOP2,XNBODY,FSTOP2
      WRITE OUTPUT TAPE 6,740,NRECRD ,NBODY,XJDO,TMAX,
     1FSTOP2,  (LWORC(I),I=1,22  ),(PLANET(I),I=1,2)
  740 FORMAT(20H  BCD  TAPE  HEADING///22H  RECORD  LENGTH      ,I4/
```

```
PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                    7/01/64        PAGE 21

     122H  BODY  NUMBER=        ,I4/          25H  NUMBER  OF  BODIES=   1/
     2          22H  START  DATE=          ,F10.2/22H  END  DATE=
     3,F10.2/
     4          22H  STEP  SIZE=           ,F10.2//1X,12A6/1X,12A6////)
      GO TO 730
C
C*****                                                                  *****
C
  727 CONTINUE
      WRITE OUTPUT TAPE 6,67,KTAPO,KCHAN
      PRINT 67,KTAPO,KCHAN
      NT=1
      PAUSE 77777
      CALL SONR (KTAPE)
      REWIND KTAPE
C     BCD HEADING FOR EPHEMERIS TAPE
      WRITE TAPE KTAPE,(KWORD(I),I=1,22  ),(PLANET(I),I=1,2)
      WRITE TAPE KTAPE,XBODY,XCONTR,XJDC,TMAX,FSTOP2,XNBODY,FSTCP2
      WRITE OUTPUT TAPE 6,740,NRECRD ,NBODY,XJDC,TMAX,
     1          FSTOP2,(KWORD(I),I=1,22  ),(PLANET(I),I=1,2)
C
C
C*****                                                                  *****
C
  730 CONTINUE
C     ELAPST=XJDC-XJDO
      WRITE OUTPUT TAPE 6,732,ITERAX,SIG,XJD,ELAPST,XNUM,SIGSQ
     1                        ,  VXM,VYM,VZM
  732 FORMAT(28H  PLOD  HAS  CONVERGED  AT  ,I5, 29H  ITERATIONS//
     1          33H  AND  A  SIGMA  VALUE  OF. .....,E16.8//
     342H           JULIAN  DATE.....,F12.2//
     442H           ELAPSED  TIME  IN  DAYS.....,F12.2//
     542H           NUMBER  OF  INTEGRATION  STEPS..,F12.0//
     742H           SIGMA  SQUARE  X  N.....,E16.8//
     814H           X  =F16.8,6H  Y  =F16.8,6H  Z  =F16.8//
     2          45H  PLOD  WILL  BEGIN  TO  WRITE  AN  EPHEMERIS///)
C     SET ALL FLAGS FOR EPHM WRITE AND RESIDUAL WRITE
      NEPHM=1
      JAM=2
C     XJC=XJDO
      MAFLAG=3
      NWRITE=1
```

```
PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                    7/01/64        PAGE 22

      LAM=2
      MPRINT=2
C
      WRITE OUTPUT TAPE 6,526,((XSTATS(I,J),I=1,3),J=1,3)
     1                  ,(FMAX(I),I=1,3),(FMIN(I),I=1,3)
      WRITE OUTPUT TAPE 6,529,(( YSTATS(3,J),(YSTATS(I,J),I=1,2)),J=1,3)
     1,FMAX(6),(FMAX(I),I=4,5),FMIN(6),(FMIN(I),I=4,5)
      GO TO 65
C
C*****                                                                  *****
C
  600 CONTINUE
      WRITE OUTPUT TAPE 6,93
   93 FORMAT(1H1,79H                                                  **********
     1    SUMMARY    **********/    )
      WRITE OUTPUT TAPE 6,1006,(KWCRC(I),I=1,22  ),(PLANET(I),I=1,2),
     1(KWORD(I),I=1,22  ),NRECRD,NBODY,XJDC,TMAX,H,FSTOP1,
     2FSTOP2,NC ,IO ,CS,STEST,EPSILN,CC,SOCUT,SOIN,MEAN,SIG
 1006 FORMAT(38H    GENERAL  IDENTIFICATION  FOR  PLOD/
     12(1X,12A6/),1X,1245/1X,10A6//26H  RECORD  LENGTH          ,I14,
     225H  BODY  NUMBER           ,I15/
     326H  START  DATE            ,F14.2,26H  MAX  DATE              F
     414.2/25H  INTEGRATION  STEP  SIZE,F15.2,25H  RESIDUAL  STEP  SIZE
     5  ,F15.2/25H  EPHEMERIS  STEP  SIZE  ,F15.2,25H  NUMBER  DIFFS.
     6      ,I15/25H  INITIAL  PT.           ,I15,20H  DIFF  CONVERGENCE
     7 ,F20.8/14H  SIGSQ  TEST ,E26.8,12H  RMS  TEST ,E28.8 7H  CC  =E33
     8.8,HH  SCOUT=E32.8/7H  SOIN=E33.8,2  MEAN  MOTION  FLAG      ,I15
     9/24H  COMPUTER  SIGMA  IS   ,E16.8//)
      GO TO (94,94,3002,95),MPRINT
   94 WRITE OUTPUT TAPE 6,3001,(KWCRC(I),I=1,22),(PLANET(I),I=1,2),
     1    XBODY,XCONTR,XJDC,TMAX,FSTCP2,XNBODY,FSTCP2
 3001 FORMAT(46H  FIRST  RECORD  BCD  EPHEMERIS  TAPE  HEADING/
     1 2(1X,12A6/),12H  2ND RECORD/8H  BODIES,F4.1,10H TAPE TYPE,F4.1,
     2 6H START,F10.1,5H TMAX,F10.1,10H STEP SIZE,F5.1,9H BODY NO.,F4.1,
     3 10H STEP SIZE,F5.1//)
      GO TO (3002,3003),NT
 3002 WRITE OUTPUT TAPE 6,3004,(KWORD(I),I=1,22),(PLANET(I),I=1,2),
     1    XNODY,XCONTR,XJDC,TMAX,FSTCP2,XNBODY,FSTCP2
 3004 FORMAT(46H  FIRST  RECORD  BCD  RESIDUAL  TAPE  HEADING /
     1 2(1X,12A6/),12H  2ND RECORD/8H  BODIES,F4.1,10H TAPE TYPE,F4.1,
     2 6H START,F10.1,5H TMAX,F10.1,10H STEP SIZE,F5.1,9H BODY NO.,F4.1,
     3 10H STEP SIZE,F5.1//)
```

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PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                    3/01/65        PAGE 23

      GO TO 3003
   95 WRITE OUTPUT TAPE 6,96
   96 FORMAT(140,-8H //////////    NO  TAPES  WRITTEN    //////////////)
 3003 CONTINUE
      WRITE OUTPUT TAPE 6,3005,(DM(I),I=1,10),(WT(I),I=1,9)
 3005 FORMAT(27H    PLANET  INVERSE  MASSES/5F16.4/5F16.4/
     1              46H    RADIUS  VECTOR  RESIDUAL  WEIGHT  FACTOR =
     2 5E16.8 /47H    OBLIQUITY  EPSILON,  AND  SIN  ,COS  OF  IT/  )
      CALL OUTPT(EPS,1,1,COSOB,1,1,SINOB,1,1)
      WRITE OUTPUT TAPE 6,2778
 2778 FORMAT(      22H    ECLIPTIC  ELEMENTS/  )
      CALL OUTPT(ELEM,7,7)
      WRITE OUTPUT TAPE 6,3006
 3006 FORMAT(25H    ECLIPTIC  P&R  MATRIX/)
      DO 598 I=1,3
D     PP(I)=PQR(1,I)
D     PQ(I)=PQR(2,I)
D 598 PR(I)=PQR(3,I)
      CALL OUTPT (PP,3,3,PQ,3,3,PR,3,3)
      WRITE OUTPUT TAPE 6,3307
 3007 FORMAT(46H    EPOCH  POSITION  AND  VELOCITY  EQUATORIAL/)
      CALL OUTPT(XOLD,3,3,VOLD,3,3)
  528 FORMAT(1H0,103H ****  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....
     1      DELTA  X          DELTA  Y          DELTA  Z   /
     253H  MEAN  DEVIATION  .................MD=SUM(DELTA)/N   ,(3E16.8)/
     353H  SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N,(3E16.8)/
     353H  STANDARD  DEVIATION..............SD=SQRTF(SR-MD**2),(3E16.8)/
     553H  MAXIMUM  RESIDUAL ..................................,(3E16.8)/
     653H  MINIMUM  RESIDUAL ..................................,(3E16.8)/
     7/)
  529 FORMAT(103H ****  STATISTICAL  ANALYSIS  FOR  RESIDUALS  IN .....
     2 RADIUS VECTOR          COSB  DL          DLAT*DB   /
     253H  MEAN  DEVIATION  .................MD=SUM(DELTA)/N   ,(3E16.8)/
     353H  SUMS  OF  SQUARES  RESIDUALS  ...SR=SUM(DELTA**2)/N,(3E16.8)/
     353H  STANDARD  DEVIATION..............SD=SQRTF(SR-MD**2),(3E16.8)/
     553H  MAXIMUM  RESIDUAL ..................................,(3E16.8)/
     653H  MINIMUM  RESIDUAL ..................................,(3E16.8)/
     7/)
      DO 531 I=1,3
D     YSTATS(I,1)=YSTATS(I,1)/XNM
D     XSTATS(I,1)=XSTATS(I,1)/XNM
D     YSTATS(I,2)=YSTATS(I,2)/XNM


PLODMN          MAIN PROGRAM FOR PLOD CHARLES J. DEVINE                    3/01/65        PAGE 24

D     XSTATS(I,2)=XSTATS(I,2)/XNM
D     YSTATS(I,3)=SQRTF(YSTATS(I,2)-(YSTATS(I,1)**2))
D531  XSTATS(I,3)=SQRTF(XSTATS(I,2)-(XSTATS(I,1)**2))
      WRITE OUTPUT TAPE 6,528,((XSTATS(I,J),I=1,3),J=1,3)
     1              ,(FMAX(I),I=1,3),(FMIN(I),I=1,3)
      WRITE OUTPUT TAPE 6,529,(( YSTATS(3,J),(YSTATS(I,J),I=1,2)),J=1,3)
     1,FMAX(6),(FMAX(I),I=4,5),FMIN(6),(FMIN(I),I=4,5)
C
C
C
C*****************************************************************************
C     CALL RAU AND REMOVE TAPES AND EXIT
C
      GO TO (1070,1071,1072,1073),NPRINT
 1070 END FILE LTAPE
      END FILE KTAPE
      CALL RUN(LTAPE)
      CALL RUN(KTAPE)
      GO TO 1073
 1071 END FILE LTAPE
      CALL RUN(LTAPE)
      GO TO 1073
 1072 END FILE KTAPE
      CALL RUN(KTAPE)
 1073 CONTINUE
 1077 CONTINUE
      IF(IEND) 40,43,40
   43 CONTINUE
      CALL RUN(MTAPE)
      CALL RUN(NTAPE)
      PRINT 30
   30 FORMAT(1H0,34H                PLEASE REMOVE TAPES)
      CALL EXIT
      END(1,1,0,0,0,0,0,1,1,0,1,0,0,0,0,0)
```

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**FORTSZ**      MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAG. 1

*                        ORIGINALLY WRITTEN BY BEEMAN, CSC 1962                  00040
*                                                                                00050
*               PROGRAM TO INTEGRATE THE EQUATIONS OF MOTION OF A                00060
*               BODY IN A GRAVITATIONAL FIELD.  THE STARTING PROCEDURE           00070
*               EMPLOYS A TAYLORS SERIES SOLUTION TO THE TWO BODY                00080
*               PROBLEM FOLLOWED BY AN ITERATIVE PROCEDURE TO IMPROVE            00090
*               THE DIFFERENCE LINES GENERATED FROM THE TAYLORS SERIES.          00100
*                  THE CALCULATION IS ADVANCED USING THE GAUSS-JACKSON           00110
*               DIFFERENCE SCHEME.  A CORRECTOR FORMULA MAY ALSO BE              00120
*               EMPLOYED TO IMPROVE THE SOLUTION.                                00130
*                                                                                00140
*          CALLING SEQUENCE                                                      00150
*               TSX    $FORTSZ,4                                                00160
*               PZE    DER,,ECS                                                 00170
*               PZE    RLIST                                                    00180
*               TRA    ERR                                                      00190
*               YYY    ,STOP,F,TS                                               00200
*               YYY    TSTOP,F,TS                                               00210
*               ..............                                                   00220
*               YYY    TSTOP,F,TS                                               00230
*               PZE                                                             00240
*                                                                               00250
*                    WHERE...DER=ADDRESS OF THE USERS DERIVATIVE ROUTINE         00260
*                           ECS=ADDRESS OF END OF STEP ROUTINE                   00270
*                         RLIST=ADDRESS OF STEP SIZE ROUTINE                     00280
*                           ERR=ADDRESS OF ERROR RETURN                          00290
*                           YYY-PZE....ACTIVE TRIGGER                            00300
*                              =MZE....INACTIVE TRIGGER                          00310
*                         TSTOP=ADDRESS OF CURRENT TSTOP ROUTINE                 00320
*                              F=F INTERPOLATE FOR POSITION ONLY                 00330
*                               =NON ZERO...INTERPOLATE FOR POSITION             00340
*                                           AND VELOCITY                         00350
*                           TS=TIME OF T STOP                                    00360
*                      NOTE.....THE FINAL PZE IS USED TO FLAG THE END OF         00370
*                               THE TSTOP LIST                                   00380
*                                                                                00390
00004          ENTRY   FORTSZ                                                    00400
*                                                                                00670
*                          *********INITIALIZATION*********                     00680
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**FORTSZ**      MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 2

     TRANSFER VECTOR

BINARY CARD NO. FIL  SZOO
    00000  674721452460     XPAND
    00001  624444436360     SMULT
    00002  622321435460     SCALE
    00003  314563514760     INTRP

    00004  0634 00 1 01303 FORTSZ SXA     X1,1                                   00690
    00005  0674 00 2 01304         SXA     X2,2                                   00700
    00006  0634 00 4 01305         SXA     X4,4                                   00710
    00007  0500 00 0 04720         CLA     =15                                    00720
    00010  0402 00 0 65652         SUB     M                                      00730
    00011  0120 00 0 00013         TPL     **2             M /GO LARGE  GREATER THAN 15  00740
    00012  0074 00 4 01277         TSX     $75,4                                  00750
    00013  0500 00 0 65652         CLA     M                                      00760
    00014  0402 00 0 04713         SUB     =1                                     00770
    00015  0120 00 0 00017         TPL     **2                                    00780
    00016  0074 00 4 01277         TSX     $75,4           M LESS THAN ONE        00790
    00017  0500 00 0 65652         CLA     M                                      00800
    00020  0402 00 0 65653         SUB     J                                      00810
    00021  0601 00 0 03117         STO     ZMJ                                    00820
    00022  0100 00 0 00025         TZE     **3                                    00830
    00023  0120 00 0 00025         TPL     **2                                    00840
    00024  0074 00 4 01277         TSX     $75,4           ) GREATER THAN M       00850
    00025  0400 00 0 04713         ADD     =1                                     00860
    00026  0734 00 1 00000         PAX     0,1                                    00870
    00027 -0634 00 1 00316         SXC     SEM1.3,1        M-J+1 TO SEM1.3        00880
    00030  0500 00 0 65653         CLA     J                                      00890
    00031  0100 00 0 00034         TZE     **3                                    00900
    00032  0120 00 0 00034         TPL     **2                                    00910
    00033  0074 00 4 01277         TSX     $75,4           J LESS THAN ZERO       00920
    00034  0500 00 0 03117         CLA     ZMJ             ****COMPUTE NEEDED CONSTANTS  00930
    00035 -0501 00 0 04740         DPA     =02330000000000 FLOAT M-J              00940
    00036  0300 00 0 04740         FAD     =02130000000000                        00950
    00037  0601 00 0 03102         STO     FMJ                                    00960
    00040  0600 00 0 03103         STZ     FMJ+1                                  00970
    00041  0500 00 0 03117         CLA     ZMJ                                    00980
    00042  0400 00 0 03117         ADD     ZMJ                                    00990
    00043  0601 00 0 03117         STO     ZM1             =2(M-J)                01000
    00044  0560 00 0 65652         CLA     M                                      01010
    00045  0400 00 0 04713         ADD     =1                                     01020
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 3

00046  0601 00 0 03111        STO     M1              =M+1                                    01030
00047  0400 00 0 04713        ADD     =1                                                      01040
00050  0601 00 0 03112        STO     M2              =M+2                                    01050
00051  0534 00 1 03112        LXA     M2,1                                                    01060
00052 -0634 00 1 00322        SXD     SEM1,4,1                                                01070
00053  0400 00 0 04713        ADD     =1                                                      01080
00054  0601 00 0 03113        STO     M3              =M+3                                    01090
00055  0400 00 0 03113        ADD     M3                                                      01100
00056  0601 00 0 03116        STO     2M6             =2M+6                                   01110
00057  0402 00 0 04716        SUB     =6                                                      01120
00060  0601 00 0 03115        STO     2M2             =2M2                                    01130
00061  0737 00 1 00000        PAC     0,1             =-(2M+2)                                01140
00062 -0634 00 1 02142        SXD     DBL7,1                                                  01150
00063 -0634 00 1 02164        SXD     DBL11,1                                                 01160
00064  0402 00 0 04714        SUB     =2                                                      01170
00065  0601 00 0 03114        STO     2M              =2M                                     01180
00066  0401 00 0 03107        STO     FLAG            MAKE FLAG NON-ZERO FOR FIRST PASS       01190
00067  0402 00 0 04714        SUB     =2                                                      01200
00070  0601 00 0 03120        STO     2MN2            2MN2=2M-2                               01210

00071  0500 00 4 00001        CLA     1,4             SET ADDRESSING FOR NEEDED SUBROUTINES   01230
00072  0621 00 0 01335        STA     DER4                                                    01240
00073  0621 00 0 02711        STA     DER3                                                    01250
00074  0621 00 0 00340        STA     DER2                                                    01260
00075  0621 00 0 01022        STA     DER1                                                    01270
00076  0621 00 0 02534        STA     DER                                                     01280
00077  0771 00 0 00022        ARS     18                                                      01290
00100  0621 00 0 02112        STA     EOS                                                     01300
00101  0621 00 0 02427        STA     EOS1                                                    01310
00102  0500 00 4 00002        CLA     2,4                                                     01320
00103  0621 00 0 00341        STA     RLIST                                                   01330
00104  0621 00 0 02056        STA     LOOP                                                    01340
00105  0621 00 0 02405        STA     RLIST1                                                  01350
                                                                                             01360
00106  0500 00 0 04722        CLA     =38             SET INDEXING PARAMETERS                 01370
00107  0402 00 0 03114        SUB     2M                                                      01380
00110  0737 00 1 00000        PAC     0,1             -(38-2M) TO X1                          01390
00111 -0634 00 1 02620        SXD     L32,1                                                   01400
00112 -0634 00 1 02761        SXD     L72,1                                                   01410
00113  1 00002 1 00114        TXI     **1,1,2         X1=-(36-2M)                             01420
00114 -0634 00 1 01425        SXD     VS27,1                                                  01430
00115  1 00002 1 00116        TXI     **1,1,2         X1=-(34-2M)                             01440
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 4

00116 -0634 00 1 02165        SXD     DBL11+1,1                                               01450
00117 -0634 00 1 02744        SXD     DBL27,1                                                 01460
00120 -0634 00 1 02344        SXD     HV9,1                                                   01470
00121 -0634 00 1 02445        SXD     HV33,1                                                  01480
00122  1 00004 1 00123        TXI     **1,1,4         X1=-(30-2M)                             01490
00123 -0634 00 1 01172        SXD     S42,1                                                   01500
00124 -0634 00 1 01224        SXD     S45,1                                                   01510
00125 -0634 00 1 01564        SXD     VS62,1                                                  01520
00126 -0634 00 1 02556        SXD     L14,1                                                   01530
00127  1 77740 1 00130        TXI     **1,1,-32       X1=-(62-2M)                             01540
00130 -0634 00 1 01165        SXD     S41+1,1                                                 01550
00131 -0634 00 1 01225        SXD     S45+1,1                                                 01560
00132 -0634 00 1 01557        SXD     VS61+1,1                                                01570
00133  1 77774 1 00134        TXI     **1,1,-4        X1=-(60-2M)                             01580
00134 -0634 00 1 02166        SXD     DBL11+2,1                                               01590
00135 -0634 00 1 02245        SXD     DBL27+2,1                                               01600
00136 -0634 00 1 02345        SXD     HV3+1,1                                                 01610
00137 -0634 00 1 02446        SXD     HV33+1,1                                                01620
00140  1 77776 1 00141        TXI     **1,1,-2        X1=-(66-2M)                             01630
00141 -0634 00 1 01424        SXD     VS25,1                                                  01640
00142  0534 00 1 03114        LXA     2M,1                                                    01650
00143 -0634 00 1 00150        SXD     IN,1                                                    01660
00144 -0634 00 1 00156        SXD     IN0,1                                                   01670
00145 -0634 00 1 03235        SXD     IN11,1                                                  01680
00146 -0634 00 1 02632        SXD     L49,1                                                   01690
00147  0774 00 1 66117        AXT     XDL+5,1                                                 01700
00150  1 00000 1 00151   IN   TXI     **1,1,**        ***2M                                   01710
00151  0634 00 1 01040        SXA     S14,1                                                   01720
00152  0634 00 1 02172        SXA     DBL14,1                                                 01730
00153 -0634 00 1 02377        SXD     HV14,1                                                  01740
00154  0634 00 1 02622        SXA     L34,1                                                   01750
00155  0774 00 1 67477        AXT     BUFF+1,1                                                01760
00156  1 00000 1 00157   IN0  TXI     **1,1,**                                                01770
00157  0634 00 1 02450        SXA     HV34,1          =ADDR(BUFF+2M+1)                        01780
00160 -0634 00 1 03121        SXD     TRANOP,1        TRA TO X1                               01790
00161 -0634 00 1 02710        SXD     L59,1           CLOSE PREDICTOR CORRECTOR GATE          01800
00162  0500 00 0 69655        CLA     OPTION                                                  01810
00163  0402 00 0 04714        SUB     =2                                                      01820
00164 -0100 00 0 00167        TNZ     **3             TEST IF PREDICTOR CORRECTOR MODE        01830
00165  0534 00 1 03121        LXA     TRANOP,1        THIS MODE NEEDS DIFFERENCE LINE SAVING  01840
00166 -0634 00 1 02710        SXD     L59,1           OPEN PREDICTOR CORRECTOR GATE           01850
00167 -0634 00 1 02535        SXD     L9.2,1                                                  01860
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 5
                        *                                                                  01870
00170 -0100 00 0 00175          TNZ     IN1             IF P/C MODE SET LIMITS TO SAVE     01880
00171  0774 00 1 77624          AXT     -108,1          THE CORRECT NUMBER OF DIFFERENCE   01890
00172  0520 00 0 65654          ZET     N               LINES.  THIS DEPENDENT ON WHETHER  01900
00173  0774 00 1 76414          AXT     -756,1          ARE INTERGRATING VARIATIONAL EQUATIONS 01910
00174 -0634 00 1 02551          SXD     L16,1                                              01920
                        *                                                                  01930
00175  0520 00 0 65654    IN1  ZET     N               TEST FOR VARIATIONAL EQUATIONS     01940
00176  0020 00 0 00222          TRA     IN10                                               01950
00177  0774 00 1 77624          AXT     -108,1                                             01960
00200 -0634 00 1 02171          SXD     DBL12,1                                            01970
00201 -0634 00 1 02260          SXD     DBL29,1                                            01980
00202 -0634 00 1 02346          SXD     HV3+2,1                                            01990
00203 -0634 00 1 02447          SXD     HV33+2,1                                           02000
00204 -0634 00 1 02621          SXD     L33,1                                              02010
00205 -0634 00 1 02762          SXD     L73,1                                              02020
00206 -0634 00 1 03005          SXD     L92,1                                              02030
00207  0774 00 1 66266          AXT     XDL+36,1                                           02040
00210 -0634 00 1 02634          SXD     L41,1                                              02050
00211  0774 00 1 00003          AXT     3,1                                                02060
00212  0634 00 1 02173          SXA     DBL15,1                                            02070
00213  0634 00 1 02451          SXA     HV35,1                                             02080
00214  0774 00 1 77626          AXT     -106,1                                             02090
00215 -0634 00 1 02373          SXD     HV11,1                                             02100
00216  0774 00 1 66266          AXT     XDL+108,1                                          02110
00217 -0634 00 1 02372          SXD     HV1C,1                                             02120
00220 -0534 00 1 03121          LXD     TRANOP,1                                           02130
00221  0020 00 0 00251          TRA     IN12                                               02140
00222  0774 00 1 76414    IN10  AXT     -756,1          VARIATIONAL EQUATIONS PRESENT      02150
00223 -0634 00 1 02171          SXD     DBL12,1                                            02160
00224 -0634 00 1 02260          SXD     DBL29,1                                            02170
00225 -0634 00 1 02346          SXD     HV3+2,1                                            02180
00226 -0634 00 1 02447          SXD     HV33+2,1                                           02190
00227 -0634 00 1 02621          SXD     L33,1                                              02200
00230 -0634 00 1 02762          SXD     L73,1                                              02210
00231 -0634 00 1 03005          SXD     L92,1                                              02220
00232  0774 00 1 67476          AXT     BUFF,1                                             02230
00233 -0634 00 1 02634          SXD     L41,1                                              02240
00234  0774 00 1 66273          AXT     V1DL+5,1                                           02250
00235  1 00000 1 00236    IN11  TXI     *+1,1,**        **=2*                              02260
00236  0634 00 1 01432          SXA     VS3C,1          X1=(4+V1DL+2M+1)                   02270
00237  0774 00 1 00025          AXT     21,1                                               02280
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 6
00240  0634 00 1 02173          SXA     DBL15,1                                            02290
00241  0634 00 1 02451          SXA     HV35,1                                             02300
00242  0774 00 1 76416          AXT     -754,1                                             02310
00243 -0634 00 1 02373          SXD     HV11,1                                             02320
00244  0774 00 1 67476          AXT     XDL+756,1                                          02330
00245 -0634 00 1 02372          SXD     HV1C,1                                             02340
00246 -0534 00 1 03121          LXD     TRANOP,1                                           02350
00247 -0634 00 1 01654          SXD     VSR2,1          CLOSE VARIATIONAL CONVERGENCE GATE 02360
00250  0534 00 1 03121          LXA     TRANOP,1                                           02370
00251 -0634 00 1 02514    IN12  SXD     L6,1            SET TRA/NOP GATES                  02380
00252 -0634 00 1 02567          SXD     L24+2,1                                            02390
00253 -0634 00 1 02644          SXD     L46+1,1                                            02400
00254 -0634 00 1 02673          SXD     L56,1                                              02410
00255 -0634 00 1 02730          SXD     L64,1                                              02420
00256 -0634 00 1 02306          SXD     DBL38,1                                            02430
00257  0600 00 0 03110          STZ     DEPSI                                              02440
00260  0534 00 1 03121          LXA     TRANOP,1                                           02450
00261 -0634 00 1 01262          SXD     S65,1           SET CONVERGED DIFFERENCE GATE      02460
00262  0500 00 0 65660          CLA     ES                                                 02470
00263  0534 00 1 03121          LXA     TRANOP,1        SET GATE FOR CHOSEN TYPE           02480
00264  0120 00 0 00266          TPL     **2             OF CONVERGENCE TEST                02490
00265 -0534 00 1 03121          LXD     TRANOP,1                                           02500
00266 -0634 00 1 01177          SXD     S42+1,1                                            02510
00267 -0634 00 1 01571          SXD     VS63,1                                             02520
                        *                                                                  02530
                        *                                                                  02540
                        *                       *********START SOLUTION FOR EQN. OF MOTION 02550
                        *                                                                  02560
00270  0520 00 0 03102          ZET     FHU             TEST IF SHIFT IS ZERO              02570
00271  0020 00 0 00305          TRA     SEM1            NO....NEED SHIFT SO TAKE TRA       02580
00272  0515 00 1 01116          LAC     2M6,1           2M6=2M+6                           02590
00273 -0634 00 1 00300          SXD     SCM,1,1                                            02600
00274  0774 00 1 00001          AXT     0,1                                                02610
00275  0500 00 1 03122    SEM   CLA     LOG1,1          SET LOG1 TO COMPUTE FIRST SUM      02620
00276  0001 00 1 72322          STO     HUFF2,1                                            02630
00277  1 77777 1 00303          TXI     **1,1,-1                                           02640
00300  3 00000 1 00275    SEM.1 TXH     SEM,1,**                                           02650
00301  0774 00 1 03234          AXT     M0+2,1                                             02660
00302  0634 00 1 01112          SXA     S33,1                                              02670
00303  0634 00 1 01504          SXA     VS9C,1                                             02680
00304  0020 00 0 00334          TRA     SEM2                                               02690
00305  0500 00 0 03112    SEM1  CLA     M2                                                 02700
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 7

003(^  0767 00 0 00001          ALS    1                                                    02710
00307  0717 00 1 00000          PAC    0,1                                                  02720
00310 -0414 00 1 00314          SXD    SEM1,2,1                                             02730
00311  0774 00 1 00000          AXT    0,1                                                  02740
00312  0400 00 1 67706  SEM1.1  STZ    BUFF1,1          ZERO STORAGE FOR SHIFTING SERIES    02750
00313  1 77777 1 00314          TXI    *+1,1,-1                                             02760
00314  3 00000 1 00312  SEM1.2  TXH    SEM1,1,1,**                                          02770
00315  0074 00 4 00000          TSX    &XPAND,4         COMPUTE SHIFT SERIES                02780
00316  0 00000 0 03102  SEM1.3  PZE    FMJ,,**          ***M+1 AS NEED M+2 TERMS IN         02790
00317  0 00000 0 67706          PZE    BUFF1            FORMULA AS LOG1 DROPS ORDER 1       02800
00320  0074 00 4 00001          TSX    &MULT,4                                              02810
00321  0 03122 0 67706          PZE    BUFF1,,LOG1      COMPUTE SERIES FOR VELOC. AT TO IN  02820
00322  0 00000 0 72322  SEM1.4  PZE    BUFF2,,**        TERMS OF ACCEL. DIFF. AT (TO+(M-J)H) 02830
                        *                                                                   02840
00323  0774 00 1 03234          AXT    P0+2,1           SET ADDRESSING FOR SECOND           02850
00324  0560 00 0 03117          LDQ    ZMJ              SUM COMPUTATION.                    02860
00325  0200 00 0 04721          MPY    *1P                                                  02870
00326  0131 00 0 00000          XCA                                                         02880
00327  0734 00 2 00000          PAX    0,2                                                  02890
00330 -0634 00 2 00331          SXD    **+1,2                                               02900
00331  1 00000 1 00332          TXI    **+1,1,**                                            02910
00332  0634 00 1 01112          SXA    S33,1                                                02920
00333  0634 00 1 01104          SXA    VS50,1                                               02930

00334  0774 00 4 00062  SEM2 AXT    50,4             SET STARTING ITERATION COUNTER       02950
00335  0634 00 4 03106          SXA    COUNT,4                                              02960
                        *                                                                   02970
00336  0500 00 0 04742          CLA    =-1              S=-1 MEANS DER WILL COMPUTE         02980
00337  0601 00 0 65657          STO    S                DERIVATIVES FOR POSITIONS ONLY      02990
                        *                                                                   03000
00340  0074 00 4 00C90  DER2 TSX    **,4             COMPUTES INITIAL POINT DERIVATIVES  03010
                        *                             ***ADDR(DFR)                        03020
00341  0074 00 4 00CC0  RLIST TSX    **,4             PICK UP STEP SIZE FROM SUB. RLIST   03030
00342 -0603 00 0 65666          DST    H                                                    03040
00343  02a1 00 0 65666          DFMP   H                                                    03050
00344 -0603 00 0 02100          DST    HSQ                                                  03060
                        *                                                                   03070
                        *       START SOLUTION USING TAYLORS SERIES EXPANSION.              03080
                        *       **STORE C SERIES IN BC A SERIES IN BD1 B SERIES IN BD2.     03090
                        *         BD3 WILL BE USED TO STORE POWERS OF TIMES.                03100
                        *         COMPUTE AND SAVE TIMES AT STARTING POINTS IN BT. USE      03110
                        *         BX, BY, AND BZ, TO STORE COMPUTED POSITIONAL COORD.       03120


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                        *                                                                   03130
00345  0500 00 0 03102          CLA    FMJ              FMJ=FLOAT(M-J)                      03140
00346  0601 00 0 03062          STO    TEMP                                                 03150
00347  0600 00 0 03063          STZ    TEMP+1                                               03160
00350  0535 00 1 03115          LAC    2M2,1            M1=M+1                              03170
00351 -0634 00 1 00363          SXD    ST1,1                                                03180
00352  0774 00 1 00000          AXT    0,1                                                  03190
00353  0443 00 0 65666    ST DLD    H                COMPUTE STARTING POINT TIMES        03200
00354  02a1 00 0 03062          DFMP   TEMP                                                 03210
00355  0361 00 0 65670          DFAD   T                                                    03220
00356 -0603 00 1 72364          DST    BT,1             BT=TO+(M-J)H                        03230
00357  0500 00 0 03062          CLA    TEMP                                                 03240
00360  0302 00 0 04724          FSB    =1.                                                  03250
00361  0601 00 0 03062          STO    TEMP                                                 03260
00362  1 77776 1 00363          TXI    **+1,1,-2                                            03270
00363  3 00000 1 00353    ST1 TXH    ST,1,**                                              03280
                        *                                                                   03290
00364  0560 00 0 65672          LDQ    X                FIND MAX OF ABS. VALUE OF X, Y, Z   03300
00365  0500 00 0 65674          CLA    Y                                                    03310
00366  0760 00 0 00003          SSP                     ABS(Y) TO AC                        03320
00367  0765 00 0 00000          LRS    0                                                    03330
00370  0774 00 1 00001          AXT    1,1              SET X1 FOR Z MAX                    03340
00371  0040 00 0 00376          TLQ    SEM3             TRANS. IF Y MAX                     03350
00372  0500 00 0 65676          CLA    Z                X IS LARGER THAN Y                  03360
00373  0760 00 0 00003          SSP                                                         03370
00374  0040 00 0 00403          TLQ    SEM4                                                 03380
00375  1 00004 1 00403          TXI    SEM4,1,4         SET X1 TO 5 AS X IS MAX             03390
00376  0131 00 0 00000    SEM3 XCA                     Y GREATER THAN X                    03400
00377  0500 00 0 65676          CLA    Z                                                    03410
00400  0760 00 0 00003          SSP                                                         03420
00401  0040 00 0 00403          TLQ    SEM4             TRANSFER IF Z=MAX(X,Y,Z)            03430
00402  0774 00 1 00003          AXT    3,1              Y=MAX(X,Y,Z)                        03440
00403 -0520 00 1 65677    SEM4 NZT    Z+1,1                                                03450
00404  0074 00 2 01301          TSX    S80,2            ERROR RETURN AS R=0                 03460
00405  0500 00 1 65713          CLA    ZDD+1,1                                              03470
00406  0241 00 1 65677          FDP    Z+1-1                                                03480
00407  0260 00 0 04723          FMP    =.5                                                  03490
00410  0601 00 0 67604          STO    BD1+2            AZ=-MU/2R**3=MAX(VDD/2V)            03500
00411  0774 00 1 00005          AXT    5,1                                                  03510
00412  0600 00 0 67602          STZ    BD1                                                  03520
00413  0600 00 0 03062          STZ    TEMP                                                 03530
00414  0600 00 0 03064          STZ    TEMP+2                                               03540
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00415  0560 00 1 65677   SEP5 LDQ     Z+1,1                                              03950
00416  0260 00 1 65677        FMP     Z+1,1                                              03960
00417  C300 00 0 67602        FAD     BD1             COMPUTE R**2=X**2+Y**2+Z**2        03970
00420  0601 00 0 5'602        STO     BC1             =R**2                              03980
00421  0560 00 1 65705        LDQ     ZD+1,1                                             03990
00422 -0260 00 1 65677        FMP     Z+1,1           COMPUTE                            04000
00423  0300 00 0 03062        FAD     TEMP            R=RDOT                             04010
00424  0601 00 0 03062        STO     TEMP            =(X*XD+Y*YD+Z*ZD)                  04020
00425  0560 00 1 65705        LDQ     ZD+1,1                                             04030
00426  0260 00 1 65705        FMP     ZD+1,1                                             04040
00427  0300 00 0 03064        FAD     TEMP+2          =XD**2+YD**2+ZD**2                 04050
00430  0601 00 0 03064        STO     TEMP+2          =VELOCITY**2                       04060
00431  2 00002 1 00415        TIX     SEP5,1,2                                           04070
00432  0241 00 0 67602        FDP     BC1             =V**2/R**2                         04080
00433 -0600 00 0 03064        STO     TEMP+2                                             04090
00434  0500 00 0 03062        CLA     TEMP                                               04100
00435  0241 00 0 67602        FDP     BC1                                                04110
00436 -0600 00 0 03062        STO     TEMP            =RDOT/R=RDOT=R/R**2                04120
00437  0260 00 0 03062        FMP     TEMP                                               04130
00440  0601 00 0 03063        STO     TEMP+1          =(RDOT/R)**2                       04140
00441  0560 00 0 67604        LDQ     BD1+2                                              04150
00442  0260 00 0 04730        FMP     =4.                                                04160
00443  0300 00 0 03064        FAD     TEMP+2          =(V**2/R**2+4A2) OR                04170
00444  0601 00 0 03064        STO     TEMP+2          =(V**2-2MU/R)/R**2                 04180
00445  0560 00 0 67604        LDQ     BD1+2                                              04190
00446  0260 00 0 03062        FMP     TEMP                                               04200
00447  0760 00 0 00002        CHS                                                        04210
00450  0601 00 0 67605        STO     BD1+3           =A3=-A2*RDOT/R                     04220
00451  0560 00 0 67604        LDQ     BD1+2                                              04230
00452  0260 00 0 04743        FMP     =-2.                                               04240
00453  0601 00 0 70012        STO     BD              CO=-2*A2                           04250
00454  0560 00 0 67605        LDQ     BD1+3                                              04260
00455  0260 00 0 04744        FMP     =-6.                                               04270
00456  0601 00 0 70013        STO     BD+1            C1=-6*A3                           04280
00457  0560 00 0 67604        LDQ     BD1+2                                              04290
00460  0260 00 0 04726        FMP     =3.                                                04300
00461  0601 00 0 03065        STO     TEMP+3          =3*A2                              04310
00462  0560 00 0 67604        LDQ     BD1+2                                              04320
00463  0260 00 0 04725        FMP     =2.                                                04330
00464  0302 00 0 03064        FSB     TEMP+2                                             04340
00465  0131 00 0 00000        XCA                                                        04350
00466  0269 00 0 03065        FMP     TEMP+3                                             04360

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00467  0601 00 0 03065        STO     TEMP+3          =3*A2(2*A2-T2)                     04370
00470  0560 00 0 03062        LDQ     TEMP                                               04380
00471  0260 00 0 67605        FMP     BD1+3                                              04390
00472  0131 00 0 00000        XCA                                                        04400
00473  0260 00 0 04731        FMP     =15.                                               04410
00474  0302 00 0 03065        FSB     TEMP+3                                             04420
00475  0601 00 0 70014        STO     BD+2            =C2=15(RDOT/R)A3-3*A2(2*A2-T2)     04430
00476  0560 00 0 03063        LDQ     TEMP+1                                             04440
00477  0260 00 0 04736        FMP     =35.                                               04450
00500  0601 00 0 03065        STO     TEMP+3                                             04460
00501  0560 00 0 67604        LDQ     BD1+2                                              04470
00502  0260 00 0 04733        FMP     =32.                                               04480
00503  0300 00 0 03065        FAD     TEMP+3                                             04490
00504  0601 00 0 03065        STO     TEMP+3                                             04500
00505  0560 00 0 03064        LDQ     TEMP+2                                             04510
00506  0260 00 0 04746        FMP     =-15.                                              04520
00507  0300 00 0 03065        FAD     TEMP+3                                             04530
00510  0131 00 0 00000        XCA                                                        04540
00511  0260 00 0 67605        FMP     BD1+3                                              04550
00512 -0760 00 0 00003        SSM                                                        04560
00513  0601 00 0 70015        STO     BD+3            C3=-A3(35.(RDOT/R)**2+32.A2-15T2)  04570
00514  0560 00 0 67603        LDQ     BD1+3                                              04580
00515  0260 00 0 04737        FMP     =233.                                              04590
00516  0601 00 0 03065        STO     TEMP+3                                             04600
00517  0560 00 0 03064        LDQ     TEMP+2                                             04610
00520  0260 00 0 04735        FMP     =105.                                              04620
00521  0601 00 0 03066        STO     TEMP+4                                             04630
00522  0560 00 0 03063        LDQ     TEMP+1                                             04640
00523  0260 00 0 04736        FMP     =157.5                                             04650
00524  0302 00 0 03066        FSB     TEMP+4                                             04660
00525  0131 00 0 00000        XCA                                                        04670
00526  0260 00 0 03062        FMP     TEMP                                               04680
00527  0302 00 0 03065        FSB     TEMP+3                                             04690
00530  0131 00 0 00000        XCA                                                        04700
00531  0260 00 0 67605        FMP     BD1+3                                              04710
00532  0131 00 0 00000        XCA                                                        04720
00533  0260 00 0 04723        FMP     .5                                                 04730
00534  0601 00 0 70016        STO     BD+4            P1=.5A3((157.5*T1-105*T2)T-233*A3) 04740
00535  0560 00 0 03064        LDQ     TEMP+2                                             04750
00536  0260 00 0 03064        FMP     TEMP+2                                             04760
00537  0131 00 0 00000        XCA                                                        04770
00540  0260 00 0 04727        FMP     =3.75                                              04780
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00541  0601 00 0 03065          STO    TEMP+3          =3.75*T2**2                              04390
00542  0560 00 0 67604          LDQ    BD1+2                                                    04400
00543  0260 00 0 04732          FMP    =16.                                                     04410
00544  0601 00 0 03066          STO    TEMP+4                                                   04420
00545  0560 00 0 03064          LDQ    TEMP+2                                                   04430
00546  0260 00 0 04747          FMP    =-15.5                                                   04440
00547  0300 00 0 03066          FAD    TEMP+4                                                   04450
00550  0131 00 0 00007          XCA                                                             04460
00551  0260 00 0 67604          FMP    BD1+2                                                    04470
00552  0300 00 0 03065          FAD    TEMP+3                                                   04480
00553  0131 00 0 00000          XCA                                                             04490
00554  0260 00 0 67604          FMP    BD1+2                                                    04500
00555 -0760 00 0 00003          SSM                    P2=-A2((16*A2-15.5*T2)A2+3.75*T2**2)     04510
00556  0300 00 0 70016          FAD    BD+4                                                     04520
00557  0601 00 0 70016          STO    BC+4            C4=C1+P2                                 04530
                                •                                                              04540
                                •      NOTE...THE FIRST (SIMPLE) TERMS OF A AND B               04550
                                •      ARE NOT STORED OR USED                                   04560
                                •                                                              04570
00560  0500 00 0 67604          CLA    BD1+2                                                    04580
00561  0241 00 0 04726          FDP    =3.                                                      04590
00562 -0600 00 0 67621          STQ    BD2+3           B3=A2/3                                  04600
00563  0460 00 0 67605          LDQ    BD1+3                                                    04610
00564  0260 00 0 04723          FMP    =.5                                                      04620
00565  0601 00 0 67622          STO    BD2+4           B4=A3/2                                  04630
00566  0560 00 0 67604          LDQ    BD1+2                                                    04640
00567  0260 00 0 70012          FMP    BC                                                       04650
00570  0300 00 0 70014          FAD    BC+2                                                     04660
00571  0241 00 0 04745          FDP    =-12.                                                    04670
00572 -0600 00 0 67606          STQ    BD1+4           A4=-(A2*C0+C2)/12                        04680
00573  0560 00 0 67605          LDQ    BD1+3                                                    04690
00574  0260 00 0 70012          FMP    BC                                                       04700
00575  0601 00 0 03065          STO    TEMP+3                                                   04710
00576  0560 00 0 67604          LDQ    BD1+2                                                    04720
00577  0260 00 0 70013          FMP    BC+1                                                     04730
00600  0300 00 0 03065          FAD    TEMP+3                                                   04740
00601  0300 00 0 70015          FAD    BD+3                                                     04750
00602  0241 00 0 04750          FDP    =-30.                                                    04760
00603 -0600 00 0 67607          STQ    BD1+5           A5=-(A3*C0+A2*C1+C3)/20                  04770
00604  0560 00 0 70012          LDQ    BC                                                       04780
00605  0260 00 0 67606          FMP    BD1+4                                                    04790
00606  0601 00 0 03065          STO    TEMP+3                                                   04800
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00607  0460 00 0 70013          LDQ    BC+1                                                     04810
00610  0260 00 0 67605          FMP    BD1+3                                                    04820
00611  0300 00 0 03065          FAD    TEMP+3                                                   04830
00612  0601 00 0 03065          STO    TEMP+3                                                   04840
00613  0560 00 0 70014          LDQ    BD+2                                                     04850
00614  0260 00 0 67604          FMP    BD1+2                                                    04860
00615  0300 00 0 03065          FAD    TEMP+3                                                   04870
00616  0300 00 0 70016          FAD    BC+4                                                     04880
00617  0241 00 0 04751          FDP    =-30.                                                    04890
00620 -0600 00 0 67610          STQ    BD1+6           A6=-(C0*A4+C1*A3+C2*A2+C4)/30.           04900
00621  0560 00 0 70012          LDQ    BC                                                       04910
00622  0260 00 0 67621          FMP    BD2+3                                                    04920
00623  0300 00 0 70014          FAD    BD+2                                                     04930
00624  0241 00 0 04750          FDP    =-20.                                                    04940
00625 -0600 00 0 67623          STQ    BD2+5           B5=-(C0*B3+C2)/20.                       04950
00626  0560 00 0 70012          LDQ    BC                                                       04960
00627  0260 00 0 67622          FMP    BD2+4                                                    04970
00630  0601 00 0 03065          STO    TEMP+3                                                   04980
00631  0560 00 0 70013          LDQ    BD+1                                                     04990
00632  0260 00 0 67621          FMP    BD2+3                                                    05000
00633  0300 00 0 03065          FAD    TEMP+3                                                   05010
00634  0300 00 0 70015          FAD    BC+3                                                     05020
00635  0241 00 0 04751          FDP    =-30.                                                    05030
00636 -0600 00 0 67624          STQ    BD2+6           B6=-(C0*B4+C1*B3+C3)/30.                 05040
                                •                                                              05050
                                •      HAVE TAYLORS SERIES COEF.  COMPUTE FIRST APPROXIMATIONS   05060
                                •                                                              05070
                                •                                                              05080
00637  0535 00 4 03115          LAC    2M2,4           2M2=2M+2                                 05090
00640 -0614 00 4 00747          SXD    S6,4                                                     05100
00641  0535 00 4 03117          LAC    2MJ,4           2MJ=2(M-J)                               05110
00642  0634 00 4 03105          SXA    TEST,4                                                   05120
00643  0774 00 4 00000          AXT    0,4                                                      05130
                                •                      LOOP TO COMPUTE FIRST APPROXIMATIONS     05140
                                •                      TO THE M+1 STARTING POINTS               05150
00644  0754 00 4 00003    S.1   PXA    0,4                                                      05160
00645  0402 00 0 03105          SUB    TEST            TEST IF THIS IS INITIAL POINT            05170
00646 -0100 00 0 00650          TNZ    S1              IF IS WILL STORE FULL DOUBLE             05180
00647  1 77776 4 00747          TXI    S6,4,-2         PRECISION VALUE AT S7, SO DONT COMPUTE   05190
                                •                                                              05200
00650  0500 00 4 72364     S1   CLA    DT,4            PICK UP TIME                             05210
00651  0302 00 0 65870          FSB    T                                                        05220
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00652  0601 00 0 67633        STO     BD3+1           =(T-T0)                                  05230
00653  0774 00 2 00005        AXT     5,2                                                      05240
00654  0131 00 3 00000     S2 XCA                                                              05250
00655  0260 00 0 67633        FMP     BD3+1                                                    05260
00656  0601 00 2 67641        STO     BD3+7,2         =D(,I)=DT(I)*DT(I-1)                     05270
00657  2 00001 2 00654        TIX     S2,2,1                                                   05280
00660  0774 00 1 00001        AXT     1,1                                                      05290
00661  0600 00 0 03065        STZ     TEMP+3                                                   05300
00662  0600 00 0 03066        STZ     TEMP+4                                                   05310
00663  0560 00 1 67611     S3 LDQ     BD1+7,1                                                  05320
00664  0260 00 1 67641        FMP     BD3+7,1                                                  05330
00665  0300 00 0 03065        FAD     TEMP+3                                                   05340
00666  0601 00 0 03065        STO     TEMP+3          =SUM(A(I)*DT**I),I=3(1)6                 05350
00667  0560 00 1 67625        LDQ     BD2+7,1                                                  05360
00670  0260 00 1 67641        FMP     BD3+7,1                                                  05370
00671  0300 00 0 03066        FAD     TEMP+4                                                   05380
00672  0601 00 0 03066        STO     TEMP+4          =SUM(B(I)*DT**I),I=3(1)6                 05390
00673  1 00001 1 00674        TXI     **1,1,1                                                  05400
00674 -3 00004 1 00663        TXL     S3,1,4                                                   05410
00675  0300 00 0 67634        FAD     BD3+1                                                    05420
00676  0601 00 0 03066        STO     TEMP+4          =G(T)=SUM(B(J)*DT**I),J=0(1)6            05430
00677  0500 0C 0 03065        CLA     TEMP+3                                                   05440
00700  0300 00 0 04724        FAD     =1.             =F(T)=SUM(A(I)*DT**I),I=0(1)6 LESS THE   05450
00701  0601 00 0 03065        STO     TEMP+3                TERM A2*DT**2                      05460
00702  0774 00 1 00000        AXT     0,1                                                      05470
00703  0560 00 0 03065     S4 LDQ     TEMP+3          COMPUTE FROM TAYLORS EXPANSION           05480
00704  0260 00 1 65672        FMP     X,1             U(I)=U(I)+F+UD(I)*G,I=1(1)3              05490
00705  0601 00 0 03067        STO     TEMP+5          ONLY THE HIGH ORDER PART OF              05500
00706  0560 00 0 03066        LDQ     TEMP+4          THE INITIAL COORD. ARE USED)             05510
00707  0260 00 1 65700        FMP     AC,1                                                     05520
00710  0300 00 0 03067        FAD     TEMP+5                                                   05530
00711  0601 00 0 03067        STO     TEMP+5                                                   05540
00712  0560 00 1 65700        LDQ     Y00,1                                                    05550
00713  0260 00 0 04723        FMP     =.5                                                      05560
00714  0131 00 0 00000        XCA                                                              05570
00715  0260 00 0 67634        FMP     BD3+2           =A2*DT**2                                05580
00716  0300 00 0 03067        FAD     TEMP+5                                                   05590
00717  0601 00 4 67542     S5 STO     BX,4                                                     05600
00720  0600 00 4 67544        STZ     BX+1,4                                                   05610
00721  1 77674 4 00722        TXI     **1,4,-68                                                05620
00722  1 77776 1 00723        TXI     **1,1,-2                                                 05630
00723  3 77772 1 00703        TXH     S4,1,-6                                                  05640
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00724 -0523 00 0 65654        NZT     N               TEST FOR VARIATIONAL EQUATIONS           05660
00725  1 00312 4 00747        TXI     S6,4,202        SET X4 TO TWO LESS THAN ORIGINAL VALUE   05670
                        *                                                                     05680
                        *              VARIATIONAL EQUATIONS PRESENT.  USE SAME TAYLORS         05690
                        *              SERIES TO COMPUTE FIRST APPROXIMATIONS                   05700
00726  0560 00 0 67604        LDQ     BD1+2                                                    05710
00727  0260 00 0 67634        FMP     BD3+2           COMPLETE F SERIES                        05720
00730  0300 00 0 03065        FAD     TEMP+3          =F(I)=SUM(A(I)*DT**I),I=1(1)6            05730
00731  0601 00 0 03065        STO     TEMP+3                                                   05740
00732  0774 00 1 00000        AXT     0,1                                                      05750
00733  0560 00 0 03065     SV1 LDQ     TEMP+3                                                   05760
00734  0260 00 1 65714        FMP     V1,1                                                     05770
00735  0601 00 0 03067        STO     TEMP+5                                                   05780
00736  0560 00 0 03066        LDQ     TEMP+4                                                   05790
00737  0260 00 1 65760        FMP     V1D,1                                                    05800
00740  0300 00 0 03067        FAD     TEMP+5                                                   05810
00741  0601 00 4 67542        STO     BX,4            (NOTE X4=-204 TO START)                  05820
00742  0600 00 4 67543        STZ     BX+1,4                                                   05830
00743  1 77674 4 00744        TXI     **1,4,-68                                                05840
00744  1 77776 1 00745        TXI     **1,1,-2                                                 05850
00745  3 77734 1 00733        TXH     SV1,1,-36                                                05860
00746  1 02622 4 00747        TXI     **1,4,1426                                               05870
00747  3 00000 4 00644     S6 TXH     S,1,4,**                                                 05880
                        *                                                                     05890
00750  0774 00 1 00005        AXT     5,1                                                      05900
00751  0535 00 2 03117        LAC     2PJ,2                                                    05910
00752  0443 00 1 65677     S7 DLD     Z+1,1                                                    05920
00753 -0623 00 2 67542        DST     BX,2            SET INITIAL VALUES IN COORD. ARRAY AND   05930
00754 -0603 00 1 03067        DST     TEMP+5,1        SAVE INITIAL POSITION AND                05940
00755  0443 00 1 65713        DLD     ZDD+1,1         CORRESPONDING SECOND DERIVATIVES         05950
00756 -0603 00 1 03075        DST     TEMP+11,1                                                05960
00757  1 77674 2 00760        TXI     **1,2,-68                                                05970
00760  2 00002 1 00752        TIX     S7,1,2                                                   05980

00761 -0520 00 0 65654        NZT     N                                                        06000
00762  0020 00 0 00771        TRA     SITEP                                                    06010
00763  0774 00 1 00043        AXT     35,1            STORE VARIATIONAL STARTING VALUES        06020
00764  0535 00 2 03117        LAC     2PJ,2           IF VARIATIONAL EQUATIONS ARE PRESENT     06030
00765  0443 00 1 65757     Sv2 DLD     V1R+1,1                                                  06040
00766 -0603 00 2 70056        DST     BV1,2                                                    06050
00767  1 77674 2 00770        TXI     **1,2,-68                                                06060
00770  2 00002 1 00765        TIX     SV2,1,2                                                  06070
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      **FORTS2**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 15

00771  0635 00 1 03115   SITER LAC     2M2,1             2M2=2M+2                          06090
00772 -0634 00 1 01036        SXD     S13,1             SET UP LOOP TO COMPUTE            06100
00773  0774 00 4 00000        AXT     0,1               NEW SECOND DERIVATIVES            06110
00774  0754 00 1 00000   SLOOP PXA     0,1                                                 06120
00775  0402 00 0 03105        SUB     TEST              TEST IF INITIAL POSITION          06130
00776 -0100 00 0 01011        TNZ     S10               TEST SET UP AT S-2 =-(2IM-J))     06140
00777  0443 00 0 03070        DLD     TEMP+6            YES, IS INITIAL POSITION          06150
01000 -0603 00 1 66116        DST     XDL+4,1           STORE PREVIOUSLY COMPUTED         06160
01001 -0603 00 1 67476        DST     BUFF,1            DERIVATIVES                       06170
01002  0443 00 0 03072        DLD     TEMP+8                                              06180
01003 -0603 00 1 66162        DST     YDL+4,1                                             06190
01004 -0603 00 1 67602        DST     BUFF+68,1                                           06200
01005  0443 00 0 03074        DLD     TEMP+10                                             06210
01006 -0603 00 1 66226        DST     ZDL+4,1                                             06220
01007 -0603 00 1 67706        DST     BUFF+136,1                                          06230
01010  0020 00 0 01035        TRA     S13-1                                               06240
                      *                                                                   06250
01011  0443 00 1 72364    S10 DLD     BT,1              SET CURRENT TIME                  06260
01012 -0603 00 0 65670        DST     T                                                   06270
01013  0443 00 1 67542        DLD     BX,1              PICK UP CURRENT GUESS             06280
01014 -0603 00   55672        DST     X                 FOR DERIVATIVE COMPUTATION        06290
01015  0443 00 1 67646        DLD     BY,1                                                06300
01016 -0603 00 0 65674        DST     Y                                                   06310
01017  0443 00 1 67752    S11 DLD     BZ,1                                                06320
01020 -0603 00 0 65676        DST     Z                                                   06330
                      *                                                                   06340
01021  0634 00 1 01023        SXA     DER1+1,1                                            06350
01022  0774 00 4 00000   DER1 TSX     **,4              COMPUTE ACCEL....***ADDR(DER)     06360
01023  0774 00 1 00000        AXT     **,1                                                06370
                      *                                                                   06380
01024  0443 00 0 65706        DLD     XDD                                                 06390
01025 -0603 00 1 66116    S12 DST     XDL+4,1           STORE NEW ACCEL. IN               06400
01026 -0603 00 1 67476        DST     BUFF,1                                              06410
01027  0443 00 0 65712        DLD     YDD               DIFFERENCE ARRAYS.                06420
01030 -0603 00 1 66162        DST     YDL+4,1                                             06430
01031 -0603 00 1 67602        DST     BUFF+68,1         SAVE ACCELERATIONS FOR STEP DOUBLING 06440
01032  0443 00 0 65712        DLD     ZDD                                                 06450
01033 -0603 00 1 66226        DST     ZDL+4,1                                             06460
01034 -0603 00 1 67706        DST     BUFF+136,1                                          06470
01035  1 77776 1 01036        TXI     **+1,1,-2                                           06480
01036  3 00000 1 00774    S13 TXH     SLOOP,1,**        ** SET AT SITER+1                 06490
                      *                                                                   06500
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01037  0774 00 4 00003        AXT     3,4                                                 06510
01040  0774 00 1 00000    S14 AXT     **,1              **=ADDR(4+XDL+2M+1)               06520
01041  0634 00 4 01061    S15 SXA     S21,4                                               06530
01042  0634 00 1 01052        SXA     S18,1                                               06540
01043  0634 00 1 01053        SXA     S19,1                                               06550
01044  1 77776 1 01045        TXI     **+1,1,-2                                           06560
01045  0634 00 1 01051        SXA     S17,1                                               06570
01046  0534 00 2 03114        LXA     2M,2                                                06580
01047 -0634 00 2 01055    S16 SXD     S20,2                                               06590
01050  0774 00 1 00001        AXT     1,1                                                 06600
01051  0443 00 1 00000    S17 DLD     **,1              FORM NEW DIFFERENCE LINE          06610
01052  0303 00 1 00000    S18 DFSB    **,1              **S STORED FROM S15-S15+3         06620
01053 -0603 00 1 00000    S19 DST     **,1                                                06630
01054  1 00002 1 01055        TXI     **+1,1,2                                            06640
01055 -3 00000 1 01051    S20 TXL     S17,1,**          **STORED AT S16                   06650
01056  2 00002 2 01047        TIX     S16,2,2                                             06660
01057  0534 00 1 01052        LXA     S18,1                                               06670
01060  1 00044 1 01061        TXI     **+1,1,36         INCREASE ADDRESS OF DIFFERENCE LINE 06680
01061  0774 00 4 00000    S21 AXT     **,4              SO DIFFERENCE FIRST X, THEN  Y AND Z 06690
01062  2 00001 4 01041        TIX     S15,4,1                                             06700
                      *                                                                   06710
01063  0774 00 1 00000        AXT     0,1                                                 06720
01064  0774 00 2 66116        AXT     XDL+4,2           SET UP SUBROUTINE ADDRESSING      06730
01065  0634 00 2 01072    S28 SXA     S30,2             TO COMPUTE FIRST SUM              06740
01066  1 77776 2 01067        TXI     **+1,2,-2                                           06750
01067  0634 00 2 01100        SXA     S31,2                                               06760
01070  0074 00 4 00002        TSX     $SCALR,4          COMPUTE PARTIAL FIRST SUM         06770
01071  0074 00 0 72324        TSX     BUFF2+2,0                                           06780
01072  0074 00 0 00000    S30 TSX     **,0              **=CURRENT DIFFERENCE LINE        06790
01073  0074 00 0 03111        TSX     M1,0              M1=M+1                            06800
01074  0074 00 0 65672        TSX     X,0               X IS USED AS TEMP STORAGE         06810
01075  0443 00 1 65700        DLD     XC,1                                                06820
01076 -0241 00 0 65666        DFDP    H                                                   06830
01077  0303 00 0 65672        DFSB    X                                                   06840
01100 -0603 00 0 00000    S31 DST     **                FIRST SUM                         06850
01101  1 00046 2 01102        TXI     **+1,2,38                                           06860
01102  1 77776 1 01103        TXI     **+1,1,-2                                           06870
01103  3 77773 1 01065        TXH     S28,1,-5                                            06880
                      *                                                                   06890
01104  0774 00 1 00000        AXT     0,1                                                 06900
01105  0774 00 2 66114        AXT     XDL+2,2                                             06910
01106  0634 00 2 01113    S32 SXA     S34,2             COMPUTE SECOND SUM                06920
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01107  1 77776 2 01113          TXI    **1,2,-3                                              06930
01110  0634 00 2 01121          SXA    S35,2                                                 06940
01111  0774 00 4 00072          SCALR,4                                                      06950
01112  0074 00 0 00000   S33 TSX    **,0          **-ADDR(P(M-J)+Z)                         06960
01113  0074 00 7 00000   L34 TSX    **,0          ODL+2 FROM S32                            06970
01114  0074 00 0 03112          TSX    M2,0                                                  06980
01115  0074 00 0 66674          TSX    Y,0           Y USED AS TEMP. STORAGE                 06990
01116  0443 00 1 03062          DLD    TEMP,1        TEMP CONTAINS INITIAL POSITIONS         07000
01117 -0241 00 0 03100          DFDP   HSF                                                  07010
01120  0374 00 0 66674          DFSB   Y                                                    07020
01121 -0603 00 0 00000   S35 DST    **            STORE SECOND SUM                          07030
01122  1 00044 2 01123          TXI    **1,2,36                                              7040
01123  1 77776 1 01124          TXI    **1,1,-2                                              7050
01124  3 77773 1 01100          TXH    S32,1,-3                                              07060
                        *                                                                   07070
01125  0520 00 0 03107          ZET    FLAG          FLAG NON ZERO MEANS SAFT TEST           07080
01126  0020 00 0 01210          TRA    S42.5         CONVERGENCE.  GO TO S42.5 FIRST PASS     07090
                        *                                                                   07100
                        *                                                                   07110
                        *        COMPUTE CONVERGENCE TEST ELEMENT FROM CURRENT DIFFERENCE    07120
                        *          AND FROM SAVED DIFFERENCE LINES IN ODL 001,002
01127  0603 00 0 03104          STZ    EPSI                                                  07130
01130  0535 00 1 03116          LAC    2M6,1         2M6=2M+6                                07140
01131 -0634 00 1 01146          SXD    S38,1                                                 07150
01132 -0634 00 1 01164          SXD    S41,1                                                 07160
01133  0774 00 1 00000          AXT    0,1                                                   07170
01134  0774 00 2 00000          AXT    0,2                                                   07180
01135  0634 00 1 01152   S36 SXA    S39,1                                                 07190
01136  0500 00 1 66112          CLA    XDL,1                                                 07200
01137  0760 00 0 00000          SSP                                                          07210
01140  1 77776 1 01141          TXI    **1,1,-2                                              07220
01141  0560 00 1 66112   S37 LDQ    XDL,1         FIND MAX. ELEMENT IN CURRENT DIFF. LN.  07230
01142  0760 00 0 00000          LXS    0                                                     07240
01143  0040 00 0 01145          TLQ    **2           TRANSFER IF PREVIOUS DIFF. GREATER      07250
01144  0131 00 2 00000          XCA                                                          07260
01145  1 77776 1 01140          TXI    **1,1,-2                                              07270
01146  3 00000 1 01141   S38 TXH    S37,1,**      ***2M+6                                 07280
01147  0601 00 0 03076          STQ    TEMP+12       SAVE MAXIMUM ELEMENT                    07290
01150 -0520 00 0 03076          NZT    TEMP+12                                               07300
01151  1 77674 2 01166          TXI    S41+2,2,-68   SKIP EPSI COMPUTATION IF FULL DIFF LN.   07310
01152  0774 00 1 00000   S39 AXT    **,1                                                  07320
01153  0443 00 1 66112   S40 DLD    XDL,1                                                 07330
01154  0203 00 2 70012          DFSB   BD,2                                                  07340


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01155  0760 00 0 00003          SSP                                                          07350
01156  0241 00 0 03076          FDP    TEMP+12       *(NEW DIFF.-OLD DIFF.)/MAX. ELEMENT     07360
01157  0500 00 0 03104          CLA    EPSI                                                  07370
01160  0040 00 0 01162          TLQ    **2           CHOOSE LARGEST ELEMENT AS NEW EPSI      07380
01161 -0600 00 0 03104          STO    EPSI                                                  07390
01162  1 77776 1 01163          TXI    **1,1,-2                                              07400
01163  1 77776 2 01164          TXI    **1,2,-2                                              07410
01164  3 00000 1 01153   S41 TXH    S40,1,**      ***-(62-2M)                             07420
01165  1 00000 2 01166          TXI    **1,2,**      ***-(62-2M)                             07430
01166 -0534 00 4 01164          LXD    S41,4                                                 07440
01167  1 77734 4 01170          TXI    **1,4,-36                                             07450
01170 -0634 00 4 01146          SXD    S38,4                                                 07460
01171 -0634 00 4 01164          SXD    S41,4                                                 07470
01172  1 00000 1 01173   S42 TXI    **1,1,**      ***-(30-2M)                             07480
01173  3 77624 1 01135          TXH    S36,1,-108                                            07490

01174  0500 00 0 03104          CLA    EPSI          TEST FOR CONVERGED DIFFERENCE LINES     07510
01175  0396 00 0 65660          FSM    ES                                                    07520
01176  0120 00 0 01210          TPL    S42.5         TRANSFER IF NO CONVERGENCE              07530
01177  0761 00 0 01203   S42.1 NOP    S42.4         NOP REPLACED BY TRA IF                  07540
01200 -0534 00 1 03121   S42.3 LXD    TRANOP,1      USING MAX. CONVERGENCE TEST             07550
01201 -0534 00 1 01262          SXD    S65,1                                                 07560
01202  0020 00 0 01227          TRA    S50                                                   07570

01203  0601 00 0 03076   S42.4 ST     TEMP+12       HAS PASSED CONVERGENCE TEST             07590
01204  0302 00 0 03110          FS     DEPSI         NOW SEE IF PASSES MAXIMUM               07600
01205  0100 00 0 01200          TZE    S42.3         POSSIBLE CONVERGENCE TEST               07610
01206  0500 00 0 03076          CLA    TEMP+12       NO...BACK FOR ANOTHER ITERATION         07620
01207  0601 00 0 03110          STO    DEPSI                                                 07630

01210  0535 00 1 03116   S42.5 LAC    2M6,1         2M6=2M+6                                07650
01211 -0634 00 1 01220          SXD    S44,1                                                 07660
01212  0774 00 1 00000          AXT    0,1                                                   07670
01213  0774 00 2 00000          AXT    0,2                                                   07680
01214  0443 00 1 66112   S43 DLD    XDL,1         SAVE CURRENT DIFFERENCE FOR NEXT PASS   07690
01215 -0603 00 2 70012          DST    BD,2                                                  07700
01216  1 77776 1 01217          TXI    **1,1,-2                                              07710
01217  1 77776 2 01220          TXI    **1,2,-2                                              07720
01220  3 00000 1 01214   S44 TXH    S43,1,**                                              07730
01221 -0534 00 4 01220          LXD    S44,4                                                 07740
01222  1 77734 4 01223          TXI    **1,4,-36                                             07750
01223 -0634 00 4 01220          SXD    S44,4                                                 07760
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01224  1 00000 1 01225     S45 TXI    **+1,1,**          ***-(30-2M)                          07770
01225  1 00000 2 01226         TXI    **+1,2,**          ***-(62-2M)                          07760
01226  3 77624 1 01214         TXH    S43,1,-108                                              07790
                                                                                              07800
01227  0535 00 1 03115     S50 LAC    2M2,1              COMPUTE COORDINATES AND STORE        07810
01230 -0634 00 1 01257         SXD    S60,1              IN ARRAYS BX, BY BX                  07820
01231  0774 00 1 00000         AXT    0,1                                                     07830
01232  0774 00 4 03232         AXT    P0+4                                                    07840
01233  0634 00 4 01243     S51 SXA    S56,4                                                   07850
01234  0774 00 2 66112         AXT    XDL,2                                                   07860
01235  0754 00 1 00000     S52 PXA    0,1                TEST IF THIS IS GIVEN COORDINATE     07870
01236  0402 30 0 03165         SUB    TEST                                                    07880
01237 -0100 00 0 01241         TNZ    S55                                                     07890
01240  1 77776 1 01235         TXI    S59,1,-2                                                07900
                                                                                              07910
01241  0634 00 2 01244     S53 SXA    S57,2              NOTE SCALR RETURNS ANS IN AC-MQ      07920
01242  0074 00 4 00002         TSX    SCALR,4            ADDR(P(0+I)),I=0(1)M                 07930
01243  0074 00 0 00000     S56 TSX    **,0               ADDR OF CURRENT DIFFERENCE LINE      07940
01244  0074 00 0 00000     S57 TSX    **,0               ADDR OF CURRENT DIFFERENCE LINE      07950
01245  0074 00 0 03113         TSX    P3,0               P3= P+3                              07960
01246  0074 00 0 65676         TSX    Z,0                USE Z AS DUMMY STORAGE               07970
01247  0261 00 0 03100         DFMP   HSQ                                                     07980
01250 -0603 00 1 07542         DST    BX,1                                                    07990
01251  1 00044 2 01252         TXI    **+1,2,36                                              08000
01252  1 77674 1 01253         TXI    **+1,1,-68                                             08010
01253  3 77464 1 01241         TXH    S55,1,-294                                             08020
01254  1 00312 1 01255         TXI    **+1,1,202                                             08030
01255  0534 00 4 01243     S59 LXA    S56,4                                                  08040
01256  1 00044 4 01257         TXI    **+1,4,36                                              08050
01257  3 00000 1 01233         TXH    S51,1,**                                               08060
                                                                                              08070
01260  0520 00 0 03107         ZET    FLAG               IF FIRST PASS CANT MAKE CONVERGENCE  08080
01261  0020 00 0 01273         TRA    S70                TEST SO SKIP                         08090
01262  0761 00 0 01307     S65 NOP    VAR                NOP REPLACED BY TRA IF GET CONVERGLNCE 08100
01263  0500 00 0 03106         CLA    COUNT              NO CONVERGENCE                       08110
01264  0407 00 0 04713         SUB    =1                 TEST COUNTER IF NOT YET              08120
01265  0601 00 0 03106         STO    COUNT              ZERO, REDUCE BY ONE AND              08130
01266 -0100 00 0 03771         TNZ    SITER              GO BACK FOR NEXT ITERATION           08140
01267  0500 00 0 03110         CLA    DEPSI              TEST TO INSURE AGAINST LOOP CAUSED BY 08150
01270 -0120 00 0 01307         TMI    VAR                MAXIMUM CONVERGENCE TEST             08160
01271  0560 00 0 04715         LDQ    =3                                                     08170
01272  0074 00 4 01302         TSX    ERROR,4            NO CONVERGENCE GO TO ERROR RETURN    08180
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01273  0600 00 0 04107     S70 STZ    FLAG                                                   08190
01274  0020 00 0 03771         TRA    SITER                                                  08200
01275  0560 00 0 04717     S72 LDQ    =5                                                     08210
01276  0020 00 0 01302         TRA    ERROR               BAD TSTOP RETURN                   08220
01277  0560 00 0 04714     S75 LDQ    =2                  BAD M OR J                         08230
01300  0020 00 0 01302         TRA    ERROR                                                  08240
01301  0560 00 0 04713     S80 LDQ    =1                  RADIUS=0                           08250
01302  0754 00 4 00000 ERROR PXA    3,4                 2S COMPLEMENT OF ERROR LOC. TO ADDR AC 08260
01303  0774 00 1 00000     X1  AXT    **,1                                                   08270
01304  0774 00 2 00000     X2  AXT    **,2                                                   08280
01305  0774 00 4 00000     X4  AXT    **,4                                                   08290
01306  0020 00 4 00003         TRA    3,4                 ERROR EXIT                         08300

01307 -0520 00 0 65654     VAR ZET    N                   N=0 MEANS NO VARIATIONAL EQUATIONS 08320
01310  0020 00 0 01663         TRA    SETIN                                                  08330

                       *                                                                      08350
                       *          VARIATIONAL EQUATIONS STARTING PROCEDURE.  AT THIS          08360
                       *          POINT BX, BY, BZ CONTAIN THE M+1 VALUES OF POSITION.       08370
                       *          AND BT CONTAINS THE CORRESPONDING TIMES.  BUFF2 HOLDS      08380
                       *          THE COEFFICIENTS OF -H*(1-DEL)**(M-J)/LOG(1-DEL).          08390
                       *          A FIRST GUESS FOR EACH OF THE VARIATIONS HAS BEEN          08400
                       *          MADE AND STORED FOR EACH OF THE M+1 NEEDED POINTS.         08410
                       *          WE IMPROVE THESE GUESSES BY THE SAME ITERATIVE             08420
                       *          PROCEDURE AS WAS USED TO OBTAIN THE CONVERGED              08430
                       *          VALUES FOR THE COORDINATES.  IT IS EXPECTED                08440
                       *          THAT THE VARIATIONAL EQUATIONS SATISFY THE                 08450
                       *          DIFFERENTIAL MATRIX SYSTEM (A THE 3 BY 3 MATRIX,           08460
                       *          AND V THE 3 BY 6 MATRIX OF THE VARIATIONS)                 08470
                       *                                                                     08480
                       *                    D**2*U=A*U                                       08490
                       *                                                                     08500
                       *          THE A MATRICES MUST BE COMPUTED BY THE                     08510
                       *          SUBROUTINE DER FOR A(X,Y,Z,T) WHENEVER                     08520
                       *          DER IS CALLED WITH S**1.  THE 9 DOUBLE                     08530
                       *          PRECISION COEFFICIENTS MUST BE LEFT IN THE                 08540
                       *          STORAGE ARRAY MATRIX AND ARE EXPECTED TO BE                08550
                       *          IN ROW WISE ORDER.  WE PROCEED AS FOLLOWS                  08560

01311  0600 00 0 03110         STZ    DEPSI                                                  08570
01312  0774 00 1 00002         AXT    2,1                                                    08580
01313  0634 00 1 03106         SXA    COUNT,1                                                08590
01314  0500 00 0 04714         CLA    =1                                                     08600
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 21

01315  0601 00 0 A5057        STO     S                                                       08610

01316  0635 00 1 03115        LAC     2M2,1                                                   08630
 1317 -0634 00 1 01360        SXD     VS10,1                                                  08640
01320  0600 00 0 04076        STZ     TEMP+12                                                 08650
01321  0774 00 2 00000        AXT     0,2                                                     08660
01322  0634 00 2 01346        SXA     VS6,2                                                   08670
01323  0634 00 2 01356  VS1    SXA     VS8,2           COMPUTE MATRICES FOR SECOND             08680
01324  0634 00 2 04076        SXA     TEMP+12,2       DERIVATIVE COMPUTATION                  08690
01325  0774 00 1 00002        AXT     0,1                                                     08700
01326  0443 00 2 72364        DLD     BT,2                                                    08710
01327 -0603 00 0 64670        DST     T               SET UP STORAGE FOR DER COMPUTATION      08720
01330  0443 00 2 67542  VS2    DLD     BX,2            OF MATRIX                               08730
01331 -0603 00 1 65672        DST     X,1                                                     08740
01332  1 77776 1 01333        TXI     **1,1,-2                                                08750
01333  1 77674 2 01334        TXI     **1,2,-68                                               08760
01334  3 77772 1 01330        TXH     VS2,1,-6                                                08770

01335  0074 00 4 01000  DER4   TSX     **,4            ***ADDR(DER)                            08790

01336  0503 00 0 04076  VS4    CLA     TEMP+12         TEST IF THIS IS MATRIX FOR              08810
01337  0402 00 0 03105        SUB     TEST            GIVEN POINT.                            08820
01340 -0100 00 0 01346        TNZ     VS6                                                     08830
 1341  0634 00 2 01356        LXA     VS8,2           YES.  DONT NEED FOR ITERATION           08840
01342  0774 00 4 66672        AXT     MATRIX,4        SO COMPUTE SECOND DERIVATIVES           08850
01343  0634 00 4 03027        SXA     MAT,4           AND THEN FORGET IT.                     08860
01344  0074 00 4 03013        TSX     MATMPY,4                                                08870
01345  1 77776 2 01340        TXI     VS10,2,-2                                               08880

01346  0774 00 1 00000  VS6    AXT     **,1            ***INDEX OF NEXT A MATRIX               08900
01347  0774 00 2 00000        AXT     0,2                                                     08910
01350  0443 00 2 66670  VS7    DLD     MATRIX,2        SAVE MATRIX FOR ITERATIVE               08920
01351 -0603 00 1 72424        DST     A,1             COMPUTATIONS OF SECOND DERIVATIVES      08930
01352  1 77776 1 01353        TXI     **1,1,-2                                                08940
01353  1 77776 2 01354        TXI     **1,2,-2                                                08950
01354  3 77756 2 01352        TXH     VS7,2,-18                                               08960
01355  0634 00 1 01346        SXA     VS6,1           SAVE A INDEX FOR NEXT MATRIX            08970
 1356  0774 00 2 00000  VS8    AXT     **,2                                                    08980
 1357  1 77776 2 01360        TXI     **1,2,-2                                                08990
 1360  3 00000 2 01323  VS10   TXH     VS1,2,**                                                09000
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01361  0535 00 2 03115  VLOOP LAC     2M2,2                                                   09020
01362 -0634 00 2 01374        SXD     VS14,2                                                  09030
01363  0774 00 2 72424        AXT     A,2                                                     09040
01364  0634 00 2 01027        SXA     MAT,2                                                   09050
01365  0774 00 2 00000        AXT     0,2                                                     09060
01366  0754 00 2 00000  VS12   PXA     0,2                                                     09070
01367  0402 00 0 03105        SUB     TEST            SKIP DERIVATIVE COMPUTATION IF          09080
01370 -0100 00 0 01372        TNZ     VS13            THIS IS INITIAL POINT.                  09090
01371  1 77776 2 01374        TXI     VS14,2,-2                                               09100

01372  0074 00 4 03013  VS13   TSX     MATMPY,4        MATMPY MAKES DERIVATIVE COMPUTATION     09120
01373  1 77776 2 01374        TXI     **1,2,-2                                                09130
01374  3 00000 2 01366  VS14   TXH     VS12,2,**                                               09140

01375  0535 00 1 03114        LAC     2M,1                                                    09160
01376 -0634 00 1 01420        SXD     VS23,1                                                  09170
01377  0774 00 1 00000        AXT     0,1                                                     09180
01400  0774 00 2 00000        AXT     0,2                                                     09190
01401  0443 00 2 66266  VS20   DLD     V1DL,2                                                  09200
01402 -0603 00 1 70052        DST     BVDL,1                                                  09210
01403  0443 00 2 66270        DLD     V1DL+2,2                                                09220
01404 -0603 00 1 70054        DST     BVDL+2,1                                                09230
01405  0443 00 2 66272        DLD     V1DL+4,2        MOVE OLD DIFFERENCES TO BVDL,           09240
01406 -0603 00 1 70056        DST     BVDL+4,1        MOVE NEW SECOND DERIVATIVES TO          09250
01407  0443 00 1 70012        DLD     BDV1,1          DIFFERENCE LINES AND MAKE FIRST         09260
01410 -0603 00 2 66272        DST     V1DL+4,2        STEP IN DIFFERENCING PROCESS.           09270
01411  0443 00 2 66274  VS21   DLD     V1DL+6,2                                                09280
01412 -0603 00 1 70060        DST     BVDL+6,1                                                09290
01413  0443 00 1 70012        DLD     BDV1,1                                                  09300
01414  0303 00 1 70014        DFSB    BDV1+2,1                                                09310
01415 -0603 00 2 66274        DST     V1DL+6,2                                                09320
01416  1 77776 1 01417        TXI     **1,1,-2                                                09330
01417  1 77776 2 01420        TXI     **1,2,-2                                                09340
01420  3 00000 2 01411  VS23   TXH     VS21,2,**                                               09350
01421 -0534 00 4 01430        LXD     VS23,4                                                  09360
01422  1 77734 4 01423        TXI     **1,4,-36                                               09370
01423 -0634 00 4 01420        SXD     VS23,4                                                  09380
01424  1 00000 1 01425  VS25   TXI     **1,1,**        ***=(68-2M)                             09390
01425  1 00000 2 01426  VS27   TXI     **1,2,**        ***=(36-2M)                             09400
01426  3 76570 2 01401        TXH     VS20,2,-648                                             09410
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01427 -0520 00 0 03123          NZT     2MN2                IF M=1 THE DIFFERENCE LINES HAVE        09430
01430  0020 00 0 01456          TRA     VS41                ALREADY BEEN COMPLETED                  09440

01431  0774 00 4 00022          AXT     18,4                                                        09460
01432  0774 00 1 00000  VS30    AXT     **,1                ***ADDR(4+V1DL+2M+1)                    09470
01433  0634 00 4 01453  VS32    SXA     VS40,4                                                      09480
01434  0634 00 1 01444          SXA     VS35,1                                                      09490
01435  0634 00 1 01445          SXA     VS36,1                                                      09500
01436  1 77776 1 01437          TXI     **1,1,-2                                                    09510
01437  0634 00 1 01443          SXA     VS34,1                                                      09520
01440  0534 00 2 03120          LXA     2MN2,2              2MN2=2M-2                               09530
01441 -0634 00 2 01447  VS33    SXD     VS38,2                                                      09540
01442  0774 00 1 00001          AXT     1,1                                                         09550
01443  0443 00 1 00000  VS34    DLD     **,1                COMPLETE DIFFERENCING COMPUTATION       09560
01444  0303 00 1 00000  VS35    DFSB    **,1                FOR THE VARIATIONAL EQUATIONS           09570
01445 -0603 00 1 00000  VS36    DST     **,1                                                        09580
01446  1 00002 1 01447          TXI     **1,1,2                                                     09590
01447 -3 00000 1 01443  VS38    TXL     VS34,1,**                                                   09600
01450  2 00002 2 01441          TIX     VS33,2,2                                                    09610
01451  0534 00 1 01444          LXA     VS35,1                                                      09620
 1452  1 00044 1 01453          TXI     **1,1,36                                                    09630
01453  0774 00 4 00000  VS40    AXT     **,4                                                        09640
01454  2 00001 4 01433          TIX     VS32,4,1                                                    09650

01455  0774 00 1 00000  VS41    AXT     0,1                                                         09670
01456  0774 00 2 66272          AXT     V1DL+4,2                                                    09680
01457  0634 00 2 01464  VS42    SXA     VS44,2                                                      09690
01460  1 77776 2 01461          TXI     **1,2,-2            COMPUTE FIRST SUMS FOR                  09700
01461  0634 00 2 01472          SXA     VS46,2              VARIATIONAL EQUATIONS                   09710
01462  0074 00 4 00002          TSX     SCALR,4                                                     09720
01463  0074 00 0 72324          TSX     BUFF2+2,0                                                   09730
01464  0074 00 0 00000  VS44    TSX     **,0                ***CURRENT DIFFERENCE LINE              09740
01465  0074 00 0 03111          TSX     M1,0                                                        09750
01466  0074 00 0 03076          TSX     TEMP+12,0                                                   09760
01467  0443 00 1 65760          DLD     V1D,1                                                       09770
01470 -0241 00 0 65666          DFCP    H                                                           09780
01471  0303 00 0 03076          DFSB    TEMP+12                                                     09790
01472 -0603 00 0 00000  VS46    DST     **                  FIRST SUM                               09800
01473  1 00046 2 01474          TXI     **1,2,38                                                    09810
01474  1 77776 1 01475          TXI     **1,1,-2                                                    09820
01475  3 77734 1 01457          TXH     VS42,1,-36                                                  09830
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01476  0774 00 1 00000          AXT     0,1                                                         09850
01477  0774 00 2 66270          AXT     V1DL+2,2                                                    09860
01500  0634 00 2 01505  VS48    SXA     VS52,2              COMPUTE SECOND SUM                      09870
01501  1 77776 2 01502          TXI     **1,2,-2                                                    09880
01502  0634 00 2 01513          SXA     VS54,2                                                      09890
01503  0074 00 4 00002          TSX     SCALR,4                                                     09900
01504  0074 00 0 00000  VS50    TSX     **,0                ***ADDR1P(M-J)+2)                       09910
01505  0074 00 0 00000  VS52    TSX     **,0                ***CURRENT DIFFERENCE LINE              09920
01506  0074 00 0 03112          TSX     M2,0                                                        09930
01507  0074 00 0 03076          TSX     TEMP+12,0                                                   09940
01510  0443 00 1 65714          DLD     V1,1                                                        09950
01511 -0241 00 0 03100          DFCP    HSQ                                                         09960
01512  0303 00 0 03076          DFSB    TEMP+12                                                     09970
01513 -0603 00 0 00000  VS54    DST     **                  SECOND SUM                              09980
01514  1 00046 2 01515          TXI     **1,2,38                                                    09990
01515  1 77776 1 01516          TXI     **1,1,-2                                                    10000
01516  3 77734 1 01500          TXH     VS48,1,-36                                                  10010

01517 -0520 00 0 03107          NZT     FLAG                FLAG=0 ON FIRST PASS. CANT              10030
01520  0020 00 0 01614          TRA     VS68                MAKE CONVERGENCE TEST SO SKIP           10040

                        *               COMPUTE CONVERGENCE TEST ELEMENT FROM CURRENT DIFFERENCE     10060
                        *               LINES AND SAVED DIFFERENCE LINES IN BUFF.                   10070

01521  0600 00 0 03104          STZ     EPSI                                                        10090
01522  0535 00 1 03116          LAC     2M6,1                                                       10100
01523 -0634 00 1 01540          SXD     VS58,1                                                      10110
01524 -0634 00 1 01556          SXD     VS61,1                                                      10120
01525  0774 00 1 00000          AXT     0,1                                                         10130
01526  0774 00 2 00000          AXT     0,2                                                         10140
01527  0634 00 1 01544  VS56    SXA     VS59,1                                                      10150
01530  0500 00 1 66266          CLA     V1DL,1                                                      10160
01531  0760 00 0 00023          SSP                                                                 10170
01532  1 77776 1 01533          TXI     **1,1,-2                                                    10180
01533  0500 00 1 66266  VS57    LDQ     V1DL,1              FIND MAX. ELEMENT IN CURRENT DIFF. LN.  10190
01534  0765 00 0 00000          LRS     0                                                           10200
01535  0040 00 0 01537          TLQ     **2                 TRANSFER IF PREVIOUS DIFF. GREATER      10210
01536  0131 00 0 00000          XCA                                                                 10220
01537  1 77776 1 01540          TXI     **1,1,-2                                                    10230
01540  3 00000 1 01533  VS58    TXH     VS57,1,**           ***-(2M+6) ORIGINALLY                   10240
01541  2601 00 0 03076          STQ     TEMP+12             SAVE MAXIMUM ELEMENT                    10250
01542 -0520 00 0 03076          NZT     TEMP+12                                                     10260
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01543' 1 77674 2 01560        TXI     VS61+2,2,-68        SKIP EPSI COMPUTATION IF NULL DIFF LN.   10270
01544  0774 00 1 00000  VS59  AXT     **,1                                                         10280
01545  0443 00 1 66266  VS60  DLD     V1DL,1                                                       10290
01546  0303 00 2 70  2        DFSB    BVDL,2                                                       10300
01547  0760 00 0 00003        SSP                                                                  10310
01550  0241 00 0 03076        FDP     TEMP+12             =(NEW DIFF.-OLD DIFF.)/MAX. ELEMENT      10320
01551  0500 00 0 03104        CLA     EPSI                                                         10330
01552  0040 00 0 01554        TLW     **2                 C..OSE LARGEST ELEMENT AS NEW EPSI       10340
01553 -0600 00 0 03104        STW     EPSI                                                         10350
01554  1 77776 1 01555        TXI     *-1,1,-2                                                     10360
01555  1 77776 2 01556        TXI     **1,2,-2                                                     10370
01556  3 00000 1 01545  VS61  TXH     VS60,1,**                                                    10380
01557  1 00000 2 01560        TXI     **1,2,**             **-(62-2M)                              10390
01560 -0634 00 4 01556        LXD     VS61,4                                                       10400
01561  1 77734 4 01562        TXI     **1,4,-36                                                    10410
01562 -0634 00 4 01540        SXD     VS58,4                                                       10420
01563 -0634 00 4 01556        SXD     VS61,4                                                       10430
01564  1 00000 1 01565  VS62  TXI     **1,1,**            **-(30-2M)                               10440
01565  3 76570 1 01527        TXH     VS56,1,-648                                                  10450

01566  0500 00 0 03104        CLA     EPSI                                                         10460
01567  0306 00 0 55660        FSM     ES                  TEST FOR CONVERGENCE                     10480
01570  0120 00 0 01604        TPL     VS66                TRA IF FAIL CONVERGENCE TEST             10490
01571  0761 00 0 01577  VS63  NOP     VS65                NOP REPLACED BY TRA IF USING             10500
01572  0774 00 1 77776  VS64  AXT     -2,1                MAXIMUM CONVERGENCE CRITERION            10510
01573 -0634 00 1 01653        SXD     VSRC,1              COMPUTE ONLY CURRENT COORDINATES         10520
01574  0534 00 1 03121        LXA     IRANDP,1                                                     10530
01575 -0634 00 1 01654        SXD     VS82,1              OPEN EXIT GATE                           10540
01576  0020 00 0 01620        TRA     VS71                                                         10550
01577  0601 00 0 03076  VS65  STO     TEMP+12             MAXIMUM CONVERGENCE TEST                 10560
01600  0302 00 0 03110        FSB     DEPSI                                                        10570
01601  0100 00 0 01572        TZE     VS64                                                         10580
01602  0500 00 0 03076        CLA     TEMP+12                                                      10590
01603  0601 00 0 03110        STO     DEPSI                                                        10600

01604  0500 00 0 03106  VS66  CLA     COUNT               NO CONVERGENCE....UPDATE COUNTER         10620
01605  0402 00 0 04713        SUB     =1                                                           10630
01606  0701 00 0 03106        STO     COUNT               TEST FOR EXCESSIVE ITERATIONS            10640
01607 -0100 00 0 01616        TNZ     VS70                                                         10650
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01610  0500 00 0 03110        CLA     DEPSI               INSURE CONVERGENCE FAILURE NOT           10670
01611 -0120 00 0 01572        TMI     VS64                DUE TO LOOP IN MAX. CONVRG. TEST         10680
01612  0560 00 0 04716        LDQ     =4                                                           10690
01613  0074 00 4 01302        TSX     ERROR,4             ERROR EXIT FOR NO CONVERGENCE            10700

01614  0500 00 0 04713  VS68  CLA     =1                                                           10720
01615  0601 00 0 03107        STO     FLAG                MAKE FLAG NON ZERO                       10730

01616  0535 00 1 03115  VS70  LAC     2M2,1               COMPUTE COORDINATES AND STORE            10750
01617 -0634 00 1 0165.        SXD     VS80,1              IN BV1 ARRAY                             10760
01620  0774 00 1 00000  VS71  AXT     0,1                 VS71 IS ENTRANCE FOR EXIT PROCEDURE      10770
01621  0774 00 4 03232        AXT     PO,4                TO COMPUTE ONLY CURRENT VARIATIONS        10780
01622  0634 00 4 01637  VS72  SXA     VS76,4                                                       10790
01623  0774 00 2 66266        AXT     V1DL,2                                                       10800
01624  0754 00 1 00000  VS73  PXA     0,1                                                          10810
01625  0402 00 0 03105        SUB     TEST                TEST IF THIS GIVEN VARIATIONS            10820
01626 -0100 00 0 01635        TNZ     VS75                                                         10830
01627  0774 00 2 00044        AXT     36,2                                                         10840
01630  0443 00 2 65760  VS74  DLD     V1+36,2                                                      10850
01631 -0603 00 1 70056        DST     BV1,1               PICK UP GIVEN VARIATIONS                 10860
01632  1 77674 1 01633        TXI     **1,1,-68                                                    10870
01633  2 00002 2 01630        TIX     VS74,2,2                                                     10880
01634  1 02306 1 01651        TXI     VS79,1,1222                                                  10890

01635  0634 00 2 01640  VS75  SXA     VS77,2                                                       10910
01636  0074 00 4 00002        TSX     SCALR,4             USE ANSWER LEFT IN AC-MQ                 10920
01637  0074 00 0 00000  VS76  TSX     **,0                ADDR(P(I),I=0(1)M                        10930
01640  0074 00 0 00000  VS77  TSX     **,0                ADDR OF CURRENT DIFFERENCE LINE          10940
01641  0074 00 0 03113        TSX     M3,0                                                         10950
01642  0074 00 0 03076        TSX     TEMP+12,0                                                    10960
01643  0261 00 0 03100        DFMP    HSQ                                                          10970
01644 -0603 00 1 70056        DST     BV1,1                                                        10980
01645  1 00044 2 01646        TXI     **1,2,36                                                     10990
01646  1 77674 1 01647        TXI     **1,1,-68                                                    11000
01647  3 75470 1 01635        TXH     VS75,1,-1224                                                 11010
01650  1 02306 1 01651        TXI     **1,1,1222                                                   11020
01651  0534 00 4 01637  VS79  LXA     VS76,4                                                       11030
01652  1 00044 4 01653        TXI     **1,4,36                                                     11040
01653  3 00000 1 01622  VS80  TXH     VS72,1,**                                                    11050
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01654  0020 00 0 01361    VS82 TRA     VLOOP              TRA TO NOP UPON CONVERGENCE              11070

01655  0774 00 . 00000         AXT     0,1                VARIATIONAL DIFFERENCE LINES             11090
01656  0774 00 2 00044         AXT     36,2               HAVE CONVERGED.  SET VARIATIONS          11100
01657  0443 00 1 70056    VS84 DLD     BV1,1              TO CURRENT VALUES.                       11110
01660 -0603 00 2 65760         DST     V1+36,2                                                     11120
01661  1 77674 1 01662         TXI     **1,1,-68                                                   11130
01662  2 00002 2 01657         TIX     VS84,2,2                                                    11140

01663  0443 00 0 67542   SETIN DLD     BX                 SET CONVERGED VALUES OF                  11160
01664 -0603 00 0 65672         DST     X                  COORDINATES CORRESPONDING                11170
01665  0443 00 0 67646         DLD     BY                 TO DIFFERENCE LINE IN PROPER             11180
01666 -0603 00 0 65674         DST     Y                  STORAGE LOCATIONS SET TIME               11190
01667  0443 00 0 67752         DLD     BZ                                                          11200
01670 -0603 00 0 65675         DST     Z                                                           11210
01671  0443 00 0 72364         DLD     BT                                                          11220
01672 -0603 00 0 65670         DST     T                                                           11230
                       *                                                                         11240
                       *                  THE STARTING DIFFERENCE LINES HAVE NOW BEEN GENERATED FOR 11250
                       *                    BOTH THE POSITIONAL AND THE VARIATIONAL EQUATIONS.    11260

01673  0600 00 0 65657         STZ     S                                                           11280
01674  0500 00 0 65652         CLA     P                                                           11290
01675  0601 00 0 03104         STC     STPCHG                                                      11300
01676  0600 00 0 65656         STZ     DTAPE                                                       11310
01677  0500 00 0 03115         CLA     2M2                                                         11320
01700  0767 00 0 00001         ALS     1                  COMPUTE 4M4=4M**4                        11330
01701  0734 00 1 00000         PAX     0,1                                                         11340
01702  0534 0C 1 03106         SXA     4M4,1              =4M**4                                   11350
01703 -0634 00 1 02141         SXD     DBL6,1                                                      11360
01704  1 77776 1 01705         TXI     **1,1,-2                                                    11370
01705 -0634 00 1 02134         SXD     DBL3+1,1           =4M**2                                   11380
01706  0600 00 0 03105         STZ     CSAVE              SET DOUBLING LOCATOR                     11390
                       *                                                                         11400
01707  0600 00 0 03107   SEARCH STZ     FLAG               FLAG WILL CONTAIN THE TAG FROM TSMIN     11410
01710  0534 00 1 01355         LXA     X4,1               START SEARCH FOR NEXT T STOP             11420
01711  0500 00 1 00004      SR CLA     4,1                                                         11430
01712  0100 00 0 01715         TZE     *SR1               0=HAVE NO ACTIVE T STOPS AS 0 IS HTR     11440
01713  0120 00 0 01720         TPL     SR2                PLUS MEANS ACTIVE T STOP                 11450
01714  1 77777 1 01711         TXI     SR,1,-1            MINUS MEANS INACTIVE T STOP. EXAMINE     11460
                       *                                  NEXT TRIGGER                             11470
01715  0500 00 0 04741   SR1   CLA     =0377777777777                                              11480
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01716  0601 00 0 03072         STC     TSMIN              ALL TRIGGERS INACTIVE.  GO TO INTEGR.    11490
01717  0020 00 0 02056         TRA     LOOP                                                        11500
01720  0621 00 0 02046    SR2  STA     TSTOP              HAVE AT LEAST ONE ACTIVE T STOP          11510
01721  0625 00 0 03107         STT     FLAG               SETUP AS TSMIN, THE MINIMUM              11520
01722  0771 00 0 00022         ARS     18                 T STOP TIME                              11530
01723  0621 00 0 01724         STA     **1                                                         11540
01724  0443 00 0 00000         DLD     **                                                          11550
01725 -0603 00 0 03072         DST     TSMIN                                                       11560
01726  1 77777 1 01727    SR3  TXI     **1,1,-1           CHECK REMAINING T STOPS TO FIND          11570
01727  0500 00 1 00004         CLA     4,1                IF ANY ARE LESS THAN TSMIN               11580
01730  0100 00 0 01753         TZE     TSTEST             ..NO MORE T STOPS                        11590
01731 -0120 00 0 01726         TMI     SR3                ..NEXT TSTOP INACTIVE                    11600
01732  0771 00 0 00022         ARS     18                 ..HAVE ANOTHER T STOP                    11610
01733  0621 00 0 01734         STA     **1                                                         11620
01734  0443 00 0 00000         DLD     **                                                          11630
01735  0340 00 0 03072         CAS     TSMIN              TEST IF NEW T STOP LESS THAN TSMIN       11640
01736  0020 00 0 01726         TRA     SR3                NEW IS GREATER                           11650
01737  0020 00 0 01741         TRA     CKLOWT             ****                                     11660
01740  0020 00 0 01746         TRA     LESS               NEW IS LESS                              11670
01741  0131 00 0 00000   CKLOWT XCA                                                                11680
01742  0340 00 0 03073         CAS     TSMIN+1            COMPARE LOW ORDER WORD AS SAME HIGH      11690
01743  0020 00 0 01726         TRA     SR3                NEW IS GREATER                           11700
01744  0020 00 0 01726         TRA     SR3                NEW IS SAME SO TAKE OLD                  11710
01745  0131 00 0 00000         XCA                        NEW IS LESS                              11720
01746 -0603 00 0 03072    LESS DST     TSMIN                                                       11730
01747  0500 00 1 00004         CLA     4,1                                                         11740
01750  0621 0C 0 02046         STA     TSTOP                                                       11750
01751  0625 00 0 03107         STT     FLAG                                                        11760
01752  0020 00 0 01726         TRA     SR3                                                         11770
                       *                                                                         11780
01753  0443 00 0 65670   TSTEST DLD     T                  TEST IF TIME FOR T STOP                  11790
01754  0340 00 0 03072         CAS     TSMIN              T=TSMIN                                  11800
01755  0020 00 0 01775         TRA     TS                 T GREATER THAN TSMIN  MAKE T STOP EXIT   11810
01756  0020 00 0 01760         TRA     CKLOW              *****                                    11820
01757  0020 00 0 02056         TRA     LOOP               T LESS THAN TSMIN CONTINUE INTEGRATION   11830
01760  0131 00 0 00000   CKLOW XCA                                                                11840
01761  0340 00 0 03073         CAS     TSMIN+1                                                     11850
01762  0020 00 0 01775         TRA     TS.5               T GREATER MAKE T STOP                    11860
01763  0020 00 0 01765         TRA     TS.1               T=TSMIN  MAKE T STOP BUT SKIP INTRP.     11870
01764  0020 00 0 02056         TRA     LOOP               TO LESS THAN TSMIN CONTINUE INTG.        11880
01765  0131 00 0 00000    TS.1 XCA                                                                 11890
01766 -0603 00 0 03067         DST     TEMP               SET UP T STOP EXIT CONDITION BUT         11900
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01767  0774 00 1 00005          AXT     5,1             SKIP INTERPOLATION                      11910
01770  0443 00 1 65677  TS00    DLD     Z+1,1                                                   11920
01771 -0603 00 1 03071          DST     TEMP+7,1                                                11930
01772  2 00002 1 01770          TIX     TS00,1,2                                                11940
01773  0020 00 0 02022          TRA     TS3.1                                                   11950
                        *                                                                       11960
01774  0131 00 0 00000   TS.5 XCA                                                              11970
01775 -0603 00 0 03062     TS DST     TEMP            SAVE TIME AND CURRENT POSITION          11980
01776  0774 00 1 00005          AXT     5,1                                                     11990
01777  0443 00 1 65677    TS0 DLD     Z+1,1                                                   12000
02000 -0603 00 1 03071          DST     TEMP+7,1                                                12010
02001  2 00002 1 01777          TIX     TS0,1,2                                                 12020
02002  0774 00 1 66112          AXT     XDL,1                                                   12030
02003  0774 00 2 65672          AXT     X,2                                                     12040
02004  0634 00 1 02011    TS1 SXA     TS2,1                                                   12050
02005  0634 00 2 02015          SXA     TS3,2           INTERPOLATE FOR COORDINATES AT          12060
02006  0074 00 4 00003          TSX     $INTRP,4        T=TSMIN AND STORE IN X,Y, AND Z         12070
02007  0074 00 0 65670          TSX     T,0             TIME                                    12080
02010  0074 00 0 03072          TSX     TSMIN,0         INTERPOLATION TIME                      12090
02011  0074 00 0 00000    TS2 TSX     **,C            DIFFERENCE LINE                         12100
02012  0074 00 0 65666          TSX     H,0             STEP SIZE                               12110
02013  0074 00 0 04712          TSX     =0,C            OPTION NUMBER                           12120
02014  0074 00 0 65652          TSX     N,C             NUMBER OF DIFFERENCES                   12130
02015  0074 00 0 00000    TS3 TSX     **,C            ANSWER                                  12140
02016  0074 00 4 01275          TSX     S72,4           ERROR EXIT                              12150
02017  1 00044 1 02020          TXI     **+1,1,36                                               12160
02020  1 00002 2 02021          TXI     **+1,2,2                                                12170
02021 -3 65676 2 02004          TXL     TS1,2,Z                                                 12180
                        *                                                                       12190
02022 -0520 00 0 03107  TS3.1 NZT     FLAG            TEST IF WISH INTERPOLATE FOR VELOCITY   12200
02023  0020 00 0 02044          TRA     TS7                                                     12210
02024  0774 00 1 66112          AXT     XDL,1                                                   12220
02025  0774 00 2 65700          AXT     XD,2                                                    12230
02026  0634 00 1 02033    TS4 SXA     TS5,1                                                   12240
02027  0634 00 2 02037          SXA     TS6,2                                                   12250
02030  0074 00 4 00003          TSX     $INTRP,4                                                12260
02031  0074 00 0 65670          TSX     T,0                                                     12270
02032  0074 00 0 03072          TSX     TSMIN,0                                                 12280
02033  0074 00 0 00000    TS5 TSX     **,C                                                    12290
02034  0074 00 0 65666          TSX     H,0                                                     12300
02035  0074 00 0 04713          TSX     =1,0                                                    12310
02036  0074 00 0 65652          TSX     N,C                                                     12320
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02037  0074 00 0 00000    TS6 TSX     **,C                                                    12330
02040  0774 00 4 01275          TSX     S72,4                                                   12340
02041  1 00044 1 02042          TXI     **+1,1,36                                               12350
02042  1 00002 2 02043          TXI     **+1,2,2                                                12360
02043 -3 65704 2 02026          TXL     TS4,2,ZD                                                12370
                                                                                                12380
02044  0443 00 0 03072    TS7 DLC     TSMIN                                                   12390
02045 -0603 00 0 65670          DST     T                                                       12400
                        *                                                                       12410
02046  0074 00 4 00000  TSTOP TSX     **,4            MAKE T STOP EXIT                        12420
                        *                                                                       12430
02047  0443 00 0 03062          DLC     TEMP                                                    12440
02050 -0603 00 0 65670          DST     T               RESTORE TIME AND POSITION TO            12450
02051  0774 00 1 00005          AXT     5,1             CORRESPOND WITH DIFFERENCE LINE         12460
02052  0443 00 1 03071    TS8 DLC     TEMP+7,1                                                12470
02053 -0603 00 1 65677          DST     Z+1,1                                                   12480
02054  2 00002 1 02052          TIX     TS8,1,2                                                 12490
02055  0020 00 0 01707          TRA     SEARCH          GO FIND NEXT TSMIN                      12500
                                                                                                12510
                        *               **********START INTEGRATION LOOP                       12520
02056  0074 00 4 00000   LOOP TSX     **,4            TEST FOR STEP CHANGE...***ACCR(RLIST)   12530
02057  0774 00 1 00001          AXT     1,1                                                     12540
02060  0120 00 0 02065          TPL     *+POSIT                                                 12550
02061  0340 00 0 65666          CAS     H               H NEGATIVE. TEST FOR STEP CHANGE        12560
02062  0020 00 0 02070          TRA     HALF                                                    12570
02063  0020 00 0 02111          TRA     SAME                                                    12580
02064  1 00001 1 02100          TXI     DOUBLE,1,1                                              12590
02065  0340 00 0 65666  HPOSIT CAS     H               H POSITIVE. TEST FOR STEP CHANGE        12600
02066  1 00001 1 02100          TXI     DOUBLE,1,1      NEW H LARGER....WANT DOUBLE STEP        12610
02067  0020 00 0 02111          TRA     SAME            CONTINUE WITH SAME STEP...X1=1,         12620
                                                        HALVE STEP...X1=0, DOUBLE STEP X1=2     12630
02070 -0603 00 0 03074   HALF DST     TEMP+10         SAVE NEW STEP                           12640
02071  0500 00 0 65656          CLA     DTAPE                                                   12650
02072  0767 00 0 00001          ALS     1                                                       12660
02073  0402 00 0 65652          SLB     N                                                       12670
02074  0120 00 0 02076          TPL     **2                                                     12680
02075  0754 00 0 00000          PXA     0,0             DTAPE=2DTAPE-H UNLESS NEW               12690
02076  0601 00 0 65456          STO     DTAPE           VALUE IS NEGATIVE, THEN DTAPE=0         12700
02077  1 77777 1 02111          TXI     SAME,1,-1                                               12710
02100  0520 00 0 03104  DOUBLE ZET     $IPCHG          WANT DOUBLE ...TEST IF CAN DOUBLE       12720
02101  1 77777 1 02111          TXI     SAME,1,-1       NO, SET X1=1 AND CONTINUE               12730
02102 -0603 00 0 03074          DST     TEMP+10         SAVE NEW STEP                           12740
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      **FORTS2**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 31

02103 -0520 00 0 65656          NZT     DTAPE                                                   12750
02104  0020 00 0 02111          TRA     SAME            DTAPE=0 HENCE IS CORRECT                12760
02105  0500 00 0 65656          CLA     DTAPE           COMPUTE NEW DTAPE                       12770
02106  0400 00 0 65652          ADD     M                                                       12780
02107  0771 00 0 00001          ARS     1                                                       12790
02110  0601 00 0 65656          STO     DTAPE           DTAPE=(DTAPE+M)/2                       12800
02111  0634 00 1 02113    SAME  SXA     EOS+1,1                                                 12810

02112  0774 00 4 00000     ECS  TSX     **,4            ***ADDR(EOS).  GO TO END OF STEP RTN.   12830

02113  0774 00 1 00000          AXT     **,1                                                    12850
02114  0020 00 1 02117          TRA     LECS1,1         BRANCH TO HALVING OR                    12860
02115  0020 00 0 02120          TRA     DBL             DOUBLING PROCEDURES                     12870
02116  0020 00 0 02477          TRA     L2                                                      12880
02117  0020 00 0 02330    LECS1 TRA     HV                                                      12890

02120  0535 00 1 03106     DBL  LAC     4M4,1           DOUBLE STEP SIZE PROCEDURE              12910
02121 -0634 00 1 02135          SXD     DBL3-1                                                  12920
02122 -0634 00 1 02140          SXD     DBL5,1                                                  12930
02123  0535 00 2 03105          LAC     CSAVE,2                                                 12940
02124  0634 00 2 02127          SXA     DBL1,2                                                  12950
02125  0634 00 0 02151          SXA     DBL3,0                                                  12960
02126  0634 00 0 02152          SXA     DBL9,0                                                  12970

02127  0774 00 2 00000    DBL1  AXT     **,2                                                    12990
02130  0774 00 1 00000          AXT     0,1                                                     13000
02131  0443 00 2 67476    DBL2  DLD     BUFF,2          REORDER REQUIRED SECOND DERIVATIVES     13010
02132 -0603 00 1 72322          DST     BUFF2,1         AND STORE IN BUFF2                      13020
02133  1 77776 1 02134          TXI     **+1,1,-2                                               13030
02134  1 77776 2 02135          TXI     **+1,2,-2                                               13040
02135  3 00000 2 02137    DBL3  TXM     DBL4,2,**                                               13050
02136  1 00000 2 02142          TXI     DBL7,2,**       ***+4M                                  13060
02137  1 77776 2 02140    DBL4  TXI     **+1,2,-2                                               13070
02140  3 00000 2 02142    DBL5  TXM     DBL7,2,**                                               13080
02141  1 00000 2 02142    DBL6  TXI     DBL7,2,**       ***+4M+2                                13090
02142  3 00000 1 02131    DBL7  TXH     DBL2,1,**       ***-(2M+2)                              13100
02143  1 77674 2 02144          TXI     **+1,2,-68                                              13110
02144  0634 00 2 02127          SXA     DBL1,2                                                  13120
02145 -0534 00 2 02140          LAD     DBL5,2                                                  13130
02146  1 77674 2 02147          TXI     **+1,2,-68                                              13140
02147 -0634 00 2 02135          SXD     DBL3,2                                                  13150
02150 -0634 00 2 02140          SXD     DBL5,2                                                  13160


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02151  0774 00 1 00000    DBL8  AXT     **,1                                                    13180
02152  0774 00 2 00000    DBL9  AXT     **,2                                                    13190
02153  0774 00 4 00000          AXT     0,4                                                     13200
02154  0500 00 1 66116    DBL10 CLA     XDL+4,1         SAVE OLD DIFFERENCES IN LAST            13210
02155  0550 00 4 72322          LDQ     BUFF2,4         HALF OF BUFF.  SET FIRST HALF           13220
02156  0601 00 2 67542          STO     BUFF+36,2       TO NEW DERIVATIVES AND MOVE             13230
02157 -0600 00 1 66116          STQ     XDL+4,1         NEW DERIVATIVE LINE TO XDL              13240
02160 -0600 00 2 67476          STQ     BUFF,2          ARRAY                                   13250
02161  1 77777 1 02162          TXI     **+1,1,-1                                               13260
02162  1 77777 2 02163          TXI     **+1,2,-1                                               13270
02163  1 77777 4 02164          TXI     **+1,4,-1                                               13280
02164  3 00000 4 02154    DBL11 TXM     DBL10,4,**      ***-(2M+2)                              13290
02165  1 00000 1 02166          TXI     **+1,1,**       ***-(34-2M)                             13300
02166  1 00000 2 02167          TXI     **+1,2,**       ***-(66-2M)                             13310
02167  0634 00 1 02151          SXA     DBL8,1                                                  13320
02170  0634 00 2 02152          SXA     DBL9,2                                                  13330
02171  3 00000 1 02127    DBL12 TXH     DBL1,1,**       ***-108 OR -756                         13340

02172  0774 00 1 00000    DBL14 AXT     **,1            ***ADDR(4*XDL+2M+1)                     13360
02173  0774 00 4 00000    DBL15 AXT     **,4            ***3 OR 21                              13370
02174  0634 00 4 02214    DBL16 SXA     DBL22,4                                                 13380
02175  0634 00 1 02205          SXA     DBL19,1                                                 13390
02176  0634 00 1 02206          SXA     DBL20,1                                                 13400
02177  1 77776 1 02200          TXI     **+1,1,-2                                               13410
02200  0634 00 1 02204          SXA     DBL18,1                                                 13420
02201  0534 00 2 03114          LXA     2M,2                                                    13430
02202 -0634 00 2 02210    DBL17 SXD     DBL21,2                                                 13440
02203  0774 00 1 00001          AXT     1,1                                                     13450
02204  0443 00 1 00000    DBL18 DLD     **,1            FORM NEW DIFFERENCE LINE                13460
02205  0303 00 1 00000    DBL19 DFSB    **,1            ** S STORED FROM DBL16-DBL16+4          13470
02206 -0603 00 1 00003    DBL20 DST     **,1                                                    13480
02207  1 00002 1 02210          TXI     **+1,1,2                                                13490
02210 -3 00000 1 02204    DBL21 TXL     DBL18,1,**      ** STORED AT DBL17                      13500
02211  2 00002 2 02202          TIX     DBL17,2,2                                               13510
02212  0534 00 1 02205          LXA     DBL19,1                                                 13520
02213  1 00044 1 02214          TXI     **+1,1,36                                               13530
02214  0774 00 4 00000    DBL22 AXT     **,4                                                    13540
02215  2 00001 4 02174          TIX     DBL16,4,1                                               13550
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02216  0443 00 0 65666  DBL23 DLD    H              THIS IS ALSO USED BY HALVING PROCEDURE   13570
02217 -0241 00 0 03074        DFDP   TEMP+12                                                 13580
02220 -0603 00 0 65666        DST    H              *(OLD H)/NEW H                           13590
02221  0535 00 1 03115        LAC    2M2,1                                                   13600
02222 -0634 00 1 02240        SXD    DBL24,1                                                 13610
02223  0774 00 1 00000        AXT    0,1                                                     13620
02224  0774 00 2 00000        AXT    0,2                                                     13630
02225  0774 00 4 67542        AXT    BUFF+36,4                                               13640
02226  0634 00 4 02250        SXA    DBL28,4                                                 13650
02227  0443 00 1 66114  DBL24 DLD    XDL+2,1        COMPUTE NEW FIRST SUMS                   13660
02230  0261 00 0 65666        DFMP   H                                                       13670
02231 -0603 00 0 03076        DST    TEMP+12        * (OLD FIRST SUM)*HOLD/HNEW              13680
02232  0443 00 2 67542  DBL25 DLD    BUFF+36,2                                               13690
02233  0261 00 0 65666        DFMP   H                                                       13700
02234  0303 00 1 66116        DFSB   XDL+4,1                                                 13710
02235 -0603 00 2 67542        DST    BUFF+36,2                                               13720
02236  1 77776 1 02237        TXI    **1,1,-2                                                13730
02237  1 77776 2 02240        TXI    **1,2,                                                  13740
02240  3 00000 1 02232  DBL26 TXH    DBL25,    *                                             13750
02241 -0534 00 4 02240        LXA    DBL26,4                                                 13760
02242  1 77734 4 02243        TXI    **1,4,-36                                               13770
02243 -0634 00 4 02244        SXD    DBL26,4                                                 13780
02244  1 00004 1 02245  DBL27 TXI    **1,1,**       ***-(34-2M)                              13790
02245  1 00000 2 02246        TXI    **1,2,**       ***-(66-2M)                              13800
02246  0074 00 4 00002        SSX    SCALR,4                                                 13810
02247  0074 00 0 03124        TSX    LOG1+2,0                                                13820
02250  0074 00 0 00000  DBL28 TSX    **,0           **=CURRENT BUFF ADDR.                    13830
02251  0074 00 0 03111        TSX    M1,0                                                    13840
02252  0074 00 0 72322        TSX    BUFF2,0                                                 13850
02253  0301 00 0 03076        DFAD   TEMP+12                                                 13860
02254 -0603 00 1 66050        DST    XDL-34,1                                                13870
02255  0534 00 4 02250        LXA    DBL28,4                                                 13880
02256  1 00104 4 02257        TXI    **1,4,68                                                13890
02257  0634 00 4 02250        SXD    DBL28,4                                                 13900
02260  3 00000 1 02227  DBL29 TXH    DBL24,1,**     ***=108 OR -756                          13910

02261  0443 00 0 03074        DLC    TEMP+10                                                 13930
02262 -0603 00 0 65666        DST    H                                                       13940
02263  0261 00 0 65666        DFMP   H                                                       13950
02264 -0603 00 0 03100        DST    HSQ                                                     13960
02265  0774 00 1 00000        AXT    0,1                                                     13970
02266  0774 00 2 66114        AXT    XDL+2,2        COMPUTE SECOND SUM FOR EQUATIONS         13980


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02267  0634 00 2 02274  DBL32 SXA    DBL34,2        OF MOTION                                14000
02270  1 77776 2 02271        TXI    **1,2,-2                                                14010
02271  0634 00 2 02302        SXA    DBL35,2                                                 14020
02272  0074 00 4 00002        TSX    SCALR,4                                                 14030
02273  0074 00 0 03234        TSX    PO+2,0                                                  14040
02274  0074 00 0 00000  DBL34 TSX    **,0                                                    14050
02275  0074 00 0 03112        TSX    M2,0                                                    14060
02276  0074 00 0 03070        TSX    TEMP+6,0                                                14070
02277  0443 00 1 65672        DLD    X,1                                                     14080
02300 -0241 00 0 03100        DFDP   HSQ                                                     14090
02301  0303 00 0 03070        DFSB   TEMP+6                                                  14100
02302 -0603 00 0 00000  DBL35 DST    **                                                      14110
02303  1 00046 2 02304        TXI    **1,2,38                                                14120
02304  1 77776 1 02305        TXI    **1,1,-2                                                14130
02305  3 77773 1 02267        TXH    DBL32,1,-5                                              14140
02306  0020 00 0 02327  DBL38 TRA    DBL50          TRA REPLACED BY NOP FOR VARIATIONAL EQU. 14150

02307  0774 00 1 00000        AXT    0,1                                                     14160
02310  0634 00 2 02315  DBL42 SXA    DBL44,2                                                 14170
02311  1 77776 2 02312        TXI    **1,2,-2       COMPUTE SECOND SUMS FOR VAR. EQU.        14180
02312  0634 00 2 02323        SXA    DBL45,2                                                 14190
02313  0074 00 4 00002        TSX    SCALR,4                                                 14200
02314  0074 00 0 03234        TSX    PO+2,0                                                  14210
02315  0074 00 0 00000  DBL44 TSX    **,0                                                    14220
02316  0074 00 0 03112        TSX    M2,0                                                    14230
02317  0074 00 0 03070        TSX    TEMP+6,0                                                14240
02320  0443 00 1 65714        DLD    Y1,1                                                    14250
02321 -0241 00 0 03100        DFDP   HSQ                                                     14260
02322  0303 00 0 03070        DFSB   TEMP+6                                                  14270
02323 -0603 00 0 00000  DBL45 DST    **                                                      14280
02324  1 00046 2 02325        TXI    **1,2,38                                                14290
02325  1 77776 1 02326        TXI    **1,1,-2                                                14300
02326  3 77734 1 02310        TXH    DBL42,1,-36                                             14310

02327  0020 00 0 02474  DBL50 TRA    HV50                                                    14320

02330  0535 00 1 03115     HV LAC    2M2,1          HALVING PROCEDURE                        14350
02331 -0634 00 1 02340        SXD    HV2,1                                                   14360
02332  0774 00 1 00000        AXT    0,1                                                     14370
02333  0774 00 2 00000        AXT    0,2                                                     14380
02334  0443 00 1 66116    HV1 DLD    XDL+4,1                                                 14390
02335 -0603 00 2 67542        DST    BUFF+36,2      SAVE OLD DIFFERENCES                     14400
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 35

02336  1 77776 1 02337          TXI     **1,1,-2                                              14410
02337  1 77776 2 02340          TXI     **1,2,-2                                              14420
02340  3 00000 1 02334    HV2   TXH     HV1,1,**                                              14430
02341 -0534 00 4 02340          LXD     H,2,4                                                 14440
02342  1 77734 4 02343          TXI     **1,4,-36                                             14450
02343 -0634 00 4 02340          SXD     HV2,4                                                 14460
02344  1 00000 1 02345    HV3   TXI     **1,1,**        ***=(34-2M)                           14470
02345  1 00000 2 02346          TXI     **1,2,**        ***=(66-2M)                           14480
02346  7 00000 1 02334          TXH     HV1,1,**        ***=108 OR -756                       14490

02347  0500 00 0 03111          CLA     P1                                                    14510
02350  0601 00 0 03066          STQ     TEMP+4                                                14520
02351  0774 00 4 00036          AXT     30,4                                                  14530
02352  0774 00 1 04332          AXT     PH1,1                                                 14540
02353  0774 00 2 66120          AXT     XDL+6,2                                               14550
02354 -0634 00 4 02374    HV4   SXD     HV12,4          FORM NEW DIFFERENCES USING            14560
02355  0534 00 4 03066          LXA     TEMP+4,4        PRESTORED COEFFICIENTS FOR            14570
02356  1 77777 4 02357          TXI     **1,4,-1        SUBTABULATION                         14580
02357  0634 00 4 03066          SXA     TEMP+4,4                                              14590
02360  0634 00 1 02364    HV5   SXA     HV7,1                                                 14600
02361  0634 00 2 02365    HV6   SXA     HV8,2                                                 14610
02362  0634 00 2 02370          SXA     HV9,2                                                 14620
02363  0074 00 4 00002          TSX     SCALR,4                                               14630
02364  0074 00 0 00000    HV7   TSX     **,C            ***PH(I)                              14640
02365  0074 00 0 00000    HV8   TSX     **,C            ***DIFF. LINE                         14650
02366  0074 00 0 03066          TSX     TEMP+4,0                                              14660
02367  0074 00 0 03070          TSX     TEMP+6,0                                              14670
02370 -0603 00 0 00000    HV9   DST     **                                                    14680
02371  1 00044 2 02372          TXI     **1,2,36                                              14690
02372 -3 00000 2 02361    HV10  TXL     HV6,2,**        ***XDL+108 OR XDL+756                 14700
02373  1 00000 2 02374    HV11  TXI     **1,2,**        ***=106 OR -754                       14710
02374  1 00000 1 02375    HV12  TXI     **1,1,**                                              14720
02375 -0534 00 4 02374          LXD     HV12,4                                                14730
02376  1 77776 4 02377          TXI     **1,4,-2                                              14740
02377 -3 00000 2 02354    HV14  TXL     HV4,2,**        ***(XDL+4+2M+1)                       14750

                                                       ALTER EXIT FROM FIRST AND             14770
                                                       SECOND SUM COMPUTATION IN             14780
02400  0774 00 1 02403          AXT     HV16,1          DOUBLING PROCEDURE.  USE THAT         14790
02401  0634 00 1 02327          SXA     DBL50,1         CODE TO MAKE FIRST AND SECOND         14800
02402  0020 00 0 02216          TRA     DBL23           SUM COMPUTATION FOR HALVING           14810
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 36

02403  0774 00 1 02474    HV16  AXT     HV30,1                                                14830
02404  0634 00 1 02327          SXA     DBL50,1         RESET DOUBLING PROCEDURE              14840

02405  0074 00 4 00000    RLIST1 TSX    **,4            **=ADDR(SUBROUTINE RLIST)             14860
02406  0120 00 0 02413          TPL     HV1E                                                  14870
02407  0340 00 0 65666          CAS     H               H NEGATIVE.  TEST FOR FURTHER REDUCTION 14880
02410  0020 00 0 02416          TRA     HV2C            REDUCE STEP AGAIN                     14890
02411  0020 00 0 02431          TRA     HV3C            STEP OK                               14900
02412  0020 00 0 02431          TRA     HV3C            STEP OK                               14910

02413  0340 00 0 65666    HV1E  CAS     H               H POSITIVE.  TEST FOR FURTHER REDUCTION 14930
02414  0020 00 0 02431          TRA     HV3C            STEP OK                               14940
02415  0020 00 0 02431          TRA     HV3C            STEP OK                               14950
02416 -0520 00 0 65656    HV2C  NXT     DTAPE           REDUCE STEP AGAIN                     14960
02417  0020 00 0 02330          TRA     HV              DTAPE=0 DONT NEED TO CHANGE           14970
02420  0500 00 0 65656          CLA     DTAPE           COMPUTE NEW DTAPE                     14980
02421  0767 00 0 00001          ALS     1                                                     14990
02422  0402 00 0 65652          SUB     M                                                     15000
02423  0601 00 0 65656          STQ     DTAPE           =2DTAPE-M                             15010
02424  0100 00 0 02427          TZE     EOS1                                                  15020
02425  0120 00 0 02330          TPL     HV                                                    15030
02426  0600 00 0 65656          STZ     DTAPE                                                 15040
02427  0074 00 1 00000    EOS1  TSX     **,1            ZERO, HENCE NEED EOS TAPE DUMP.       15050
02430  0020 00 0 02330          TRA     HV              SET DTAPE=0 AND GO TO EOS             15060

02431  0535 00 1 03115    HV3C  LAC     ZM2,1                                                 15080
02432 -0634 00 1 02441          SXD     HV32,1          MOVE NEW DIFFERENCE LINES TO          15090
02433  0774 00 1 00000          AXT     0,1             STEP DOUBLING BUFFER                  15100
02434  0774 00 2 00000          AXT     0,2                                                   15110
02435  0400 00 1 66116    HV31  DLC     XDL+4,1                                               15120
02436 -0603 00 2 67476          DST     BUFF,2                                                15130
02437  1 77776 1 02440          TXI     **1,1,-2                                              15140
02440  1 77776 2 02441          TXI     **1,2,-2                                              15150
02441  3 00000 1 02435    HV32  TXH     HV31,1,**                                             15160
02442 -0534 00 4 02441          LXD     HV32,4                                                15170
02443  1 77734 4 02444          TXI     **1,4,-36                                             15180
02444 -0634 00 4 02441          SXD     HV32,4                                                15190
02445  1 00000 1 02446    HV33  TXI     **1,1,**        ***=(34-2M)                           15200
02446  1 00000 2 02447          TXI     **1,2,**        ***=(66-2M)                           15210
02447  3 00000 1 02435          TXH     HV31,1,**       ***=108 OR -756                       15220
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02450  0774 00 1 00000   HV34 AXT   **,1                ***ADDR(BUFF+2M+1)                    15240
02451  0774 00 4 00000   HV35 AXT   **,4                ***3 OR 21                            15250
02452  0634 00 4 02472   HV36 SXA   HV42,4                                                     15260
02453  0634 00 1 02463        SXA   HV39,1                                                     15270
02454  0634 00 1 02464        SXA   HV40,1                                                     15280
02455  1 77776 1 02456        TXI   **1,1,-2                                                   15290
02456  0634 00 1 02462        SXA   HV38,1                                                     15300
02457  0634 00 2 03114        LXA   2M,2                                                       15310
02460 -0634 00 2 02466   HV37 SXD   HV41,2                                                     15320
02461  0774 00 1 00001        AXT   1,1                                                        15330
02462  0443 00 1 00000   HV38 DLD   **,1                UNDIFFERENCE NEW DIFFERENCE LINE      15340
02463  0743 00 1 00000   HV39 DFSB  **,1                TO GENERATE SECOND DERIVATIVES FOR    15350
02464 -0603 00 1 00000   HV40 DST   **,1                STEP DOUBLING PROCEDURE.              15360
02465  1 00002 1 02466        TXI   **1,1,2              ** S STORED AT HV36 TO HV3644         15370
02466 -3 00000 1 02462   HV41 TXL   HV38,1,**           ** STORED AT HV 37                    15380
02467  2 00002 2 02460        TIX   HV37,2,2                                                   15390
02470  0634 00 1 02463        LXA   HV39,1                                                     15400
02471  1 03104 1 02472        TXI   **1,1,68                                                   15410
02472  0774 00 4 0 000   HV42 AXT   **,4                                                     15420
02473  2 00001 4 02452        TIX   HV36,4,1                                                   15430

02474  0600 00 0 03105   HV50 STZ   CSAVE                                                    15450
02475  0503 00 0 65652        CLA   M                    USE M TO MAKE STPCHG NON ZERO         15460
02476  0601 00 0 03104        STO   STPCHG               USE MSC TO MAKE STPCHG NON-ZERO       15470

                                                                                             15490
                                                                                             15500
02477  0774 00 2 66112     L2 AXT   XDL,2                INTEGRATE ONE STEP WITH OPEN FORMULA  15510
02500  0774 00 1 00000        AXT   0,1                  THIS LOOP FOR POSITIONS               15520
02501  0634 00 2 02524     L3 SXA   L4,2                 SET ACCRIDIFF LINE) IN CALLING SEQ.   15530
02502  0074 00 4 00002        TSX   SCAL4,4                                                    15540
02503  0074 00 0 03166        TSX   PM1,0                                                      15550
02504  0074 00 0 00000     L4 TSX   **,0                                                     15560
02505  0074 00 0 03113        TSX   M3,0                 M3=M+3                                15570
02506  0074 00 0 65756        TSX   V18,0                USE V15 AS DUMMY STORAGE              15580
02507  0261 00 0 03100        OFMP  HSQ                                                        15590
02510 -0603 00 1 65672        DST   X,1                                                        15600
02511  1 00044 2 02512        TXI   **1,2,36                                                   15610
02512  1 77776 1 02513        TXI   **1,1,-2                                                   15620
02513  3 77772 1 02521     L5 TXH   L3,1,-6                                                    15630
02514  0020 00 0 02531     L6 TRA   L9                   TRA IS REPLACED BY NOP IF HAVE        15640
02515  0774 00 1 00000        AXT   0,1                  VARIATIONAL EQUATIONS                 15650
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02516  0634 00 2 02521     L7 SXA   L8,2                                                     15660
02517  0074 00 4 00002        TSX   SCALR,4              INTEGRATE VARIATIONAL EQUATIONS       15670
02520  0074 00 0 03166        TSX   PM1,0                                                      15680
02521  0074 00 0 00000     L8 TSX   **,0                                                     15690
02522  0074 00 0 03113        TSX   M3,0                                                       15700
02523  0074 00 0 65756        TSX   V18,0                                                      15710
02524  0261 00 0 03100        OFMP  HSQ                                                        15720
02525 -0603 00 1 65714        DST   V1,1                                                       15730
02526  1 00044 2 02527        TXI   **1,2,36                                                   15740
02527  1 77776 1 02530        TXI   **1,1,-2                                                   15750
02530  3 77734 1 02516        TXH   L7,1,-36                                                   15760
                                                                                             15770
02531  0443 00 0 65670     L9 DLD   T                    INCREASE TIME TO T+H                  15780
02532  0301 00 0 65666        DFAD  H                                                          15790
02533 -0603 00 0 65670        DST   T                                                          15800
                                                                                             15810
02534  0074 00 4 00000   DER TSX   **,4                 COMPUTE NEW SECOND DERIVATIVES        15820
                                                        ***ADDR(DE')                          15830
02535  0020 00 0 02552   L9.2 TRA   L20                 NOP STORED OVER TRA IF OPTION=2        15840
02536  0535 00 1 03116        LAC   2M6,1                ....SAVE CURRENT DIFFERENCES FOR      15850
02537 -0634 00 1 02544        SXD   L12,1                PREDICTOR CORRECTOR MODE              15860
02540  0774 00 1 00000        AXT   0,1                                                        15870
02541  0443 00 1 66112   L10 DLD   XDL,1                                                     15880
02542 -0603 00 1 72322        DST   BUFF3,1                                                    15890
02543  1 77776 1 02544        TXI   **1,1,-2                                                   15900
02544  3 00000 1 02541   L12 TXH   L10,1,**                                                   15910
02545 -0534 00 2 02544        LXD   L12,2                                                      15920
02546  1 77734 2 02547        TXI   **1,2,-36                                                  15930
02547 -0634 00 2 02544        SXD   L12,2                                                      15940
02550  1 00000 1 02551   L14 TXI   **1,1,**             ***=(3C-2M)                           15950
02551  3 77624 1 02541   L16 TXH   L10,1,-108           -3*36 IS REPLACED BY-21*36 FOR VAR.   15960
                                                                                             15970
02552  0774 00 1 00000   L20 AXT   0,1                  COMPUTE FIRST AND SECOND SUMS         15980
02553  0774 00 2 00000        AXT   0,2                  AND FIRST DIFFERENCES                 15990
02554  0443 00 1 65706   L22 DLD   XDD,1                                                     16000
02555  0301 00 2 66114        DFAD  XDL+2,2                                                    16010
02556 -0603 00 2 66114        DST   XDL+2,2              =FIRST SUM                            16020
02557  0301 00 2 66112        DFAD  XDL,2                                                      16030
02560 -0603 00 2 66112        DST   XDL,2                =SECOND SUM                           16040
02561  0443 00 1 65706        DLD   XDD,1                                                      16050
02562  0303 00 2 66116        DFSB  XDL+4,2                                                    16060
02563 -0603 00 2 66116        DST   XDL+4,2              =FIRST DIFFERENCE                     16070
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02564  1 77776 1 02565          TXI     **+1,1,-2                                              16080
02565  1 77734 2 02566          TXI     **+1,2,-36                                             16090
02566  3 77772 1 02554    L24   TXH      22,1,-6                                               16100
                                                                                              16110
02567  0020 00 0 02605   L24.2  TRA     L28             TRA REPLACED BY NOP FOR VAR. EQU.      16120
02570  0774 00 1 00000          AXT     0,1                                                    16130
02571  0774 00 2 00000          AXT     0,2                                                    16140
02572  0443 00 1 66024    L25   DLD     V1DL,1                                                 16150
02573  0361 00 2 66270          DFAD    V1DL+2,2                                               16160
02574 -0603 00 2 66270          DST     V1DL+2,2        *VAR. FIRST SUM                        16170
02575  0361 00 2 66266          DFAD    V1DL,2                                                 16180
02576 -0603 00 2 66266          DST     V1DL,2          *VAR. SECOND SUM                       16190
02577  0443 00 1 66024          DLD     V1DL,1                                                 16200
02600  0363 00 2 66272          DFSB    V1DL+4,2                                               16210
02601 -0603 00 2 66272          DST     V1DL+4,2        *VAR. FIRST DIFFERENCE                 16220
02602  1 77776 1 02603          TXI     **+1,1,-2                                              16230
02603  1 77734 2 02604          TXI     **+1,2,-36                                             16240
02604  3 77734 1 02572          TXH     L25-1,1,-36                                            16250
                                                                                              16260
02605  0545 00 1 03114   L28   LAC     2M,1                                                   16270
02606 -0634 00 1 02614          SXD     L30,1                                                  16280
02607  0774 00 1 77776          AXT     -2,1                                                   16290
02610  0443 00 1 66114    L29   DLD     XDL+2,1         COMPUTE NEW DIFFERENCE LINES           16300
02611  0363 00 1 66116          DFSB    XDL+4,1                                                16310
02612 -0603 00 1 66116          DST     XDL+4,1                                                16320
02613  1 77776 1 02614          TXI     **+1,1,-2                                              16330
02614  3 00000 1 02610    L30   TXH     L29,1,**        ** LOADED AT L28+1                     16340
02615 -0534 00 2 02614          LAC     L30,2                                                  16350
02616  1 77734 2 02617          TXI     **+1,2,-36                                             16360
02617 -0634 00 2 02614          SXD     L30,2                                                  16370
02620  1 00000 1 02621    L32   TXI     **+1,1,**       ***-(38-2M)                            16380
02621 -3 00000 1 02610    L33   TXH     L29,1,**        ***-108 OR-75*                         16390
                                                                                              16400
02622  0774 00 1 00000    L34   AXT     **,1            ***ADDR(XDL+4+2M+1)                    16410
02623  0634 00 1 02630    L35   SXA     L39,1           RESTORE DIFFERENCES                    16420
02624  1 77776 1 02625          TXI     **+1,1,-2       IN CORRECT LOCATIONS                   16430
02625  0634 00 1 02627          SXA     L38,1                                                  16440
02626  0774 00 2 00001          AXT     1,2                                                    16450
02627  0443 00 2 00000    L38   DLD     **,2                                                   16460
02630 -0603 00 2 00000    L39   DST     **,2                                                   16470
02631  1 00002 2 02632          TXI     **+2,2,2                                               16480
02632 -3 00000 2 02627    L40   TXL     L38-2,**        ***2M                                  16490
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02633  1 00046 1 02634          TXI     **+1,           ***                                    16500
02634 -3 00000 1 02623    L41   TXL     L35             ***ZDL+36 OR V18DL+36                  16510
                                                                                              16520
02635  0774 00 1 00000          AXT     0,1               NISH DIFFERENCE LINE COMPUTATION     16530
02636  0774 00 2 00000          AXT     0,2               VE NEW DERIVATIVES TO DIFF LINE      16540
02637  0443 00 1 65706    L45   DLD     XDD,1                                                  16550
02640 -0603 00 2 66116          DST     XDL+**,2                                               16560
02641  1 77776 1 02642          TXI     **+1,1,-2                                              16570
02642  1 77734 2 02643          TXI     **+1-2,-36                                             16580
02643  3 7777  1 02637    L46   TXH     L45,1,-6                                               16590
                                                                                              16600
02644  0020 00 0 02654          TRA     L50             TRA ALTERED TO NOP FOR                 16610
02645  0774 00 1 00000          AXT     0,1             VARIATIONAL EQUATIONS                  16620
02646  0774 00 2 00000          AXT     0,2                                                    16630
02647  0443 00 1 66024    L47   DLD     V1DL,1                                                 16640
02650 -0603 00 2 66272          DST     V1DL+4,2                                               16650
02651  1 77776 1 02652          TXI     **+1,1,-2                                              16660
02652  1 77734 2 02653          TXI     **+1,2,-36                                             16670
02653  3 77734 1 02647    L48   TXH     L47,1,-36                                              16680
                                                                                              16690
02654 -0540 00 0 65635    L50   NZT     OPTION          IF OPTION=0 THE PROCEDURE IS COMPLETE  16700
02655  0020 00 0 02763          TRA     L20                                                    16710
                                                                                              16720
02656  0774 00 1 00000          AXT     0,1                                                    16730
02657  0774 00 2 66112          AXT     XDL,2                                                  16740
02660  0634 00 2 02663    L53   SXA     L54,2           IMPROVE COORDINATES WITH               16750
02661  0074 00 4 00002          TSX     SCALR,4         CORRECTOR FORMULA                      16760
02662  0074 00 2 03232          TSX     PD,2                                                   16770
02663  0074 00 0 00000    L54   TSX     **,0                                                   16780
02664  0074 00 0 03113          TSX     M3,0                                                   16790
02665  0074 00 0 65756          TSX     V1R,0           V18 IS USED AS TEMPORARY STORAGE       16800
02666  0261 00 0 03100          DFMP    HSQ                                                    16810
02667 -0603 00 1 65672          DST     X,1                                                    16820
02670  1 00044 2 02671          TXI     **+1,2,36                                              16830
02671  1 77776 1 02672          TXI     **+1,1,-2                                              16840
02672  3 77772 1 02660    L55   TXH     L53,1,-6                                               16850
02673  0020 00 0 02710    L56   TRA     L60             TRA REPLACED BY NOP IF                 16860
02674  0774 00 1 00000          AXT     0,1             VARIATIONAL EQUATIONS ARE PRESENT      16870
02675  0634 00 2 02700    L57   SXA     L58,2                                                  16880
02676  0074 00 4 00002          TSX     SCALR,4                                                16890
02677  0074 00 2 03232          TSX     PD,2                                                   16900
02700  0074 00 0 00000    L58   TSX     **,0                                                   16910
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02701  0074 00 0 03113          TSX     M3,C                                                16920
02702  0074 00 0 03756          TSX     V1P,0                                               16930
02703  0261 00 0 03100          DFMP    HSC                                                 16940
02704 -0603 00 1 65714          DST     V1,1                                                16950
02705  1 00044 2 02705          TXI     **1,2,36                                            16960
02706  1 77776 1 02707          TXI     **1,1,-2                                            16970
02707  3 77734 1 02677          TXH     L57,1,-36                                           16980
                                •                                                           16990
02710  0020 00 0 02763    L79 TRA     L80             TRA REPLACED BY NOP IF OPTION=2      17000
                                •                                                           17010
02711  0074 00 4 00000    DER3 TSX    **,4            PREDICTOR-CORRECTOR MODE...***DER    17020
                                •                     COMPUTE NEW DERIVATIVES              17030
02712  0774 00 1 00000    L80 AXT     0,1                                                 17040
02713  0774 00 2 00000         AXT     0,2                                                 17050
02714  0443 00 1 65706    L62 DLD     XDD,1                                               17060
02715  0301 00 2 72324         DFAC    BUFF3+2,2                                           17070
02716 -0603 00 2 66114          DST     XDL+2,2         *IMPROVED FIRST SUM                 17080
02717  0301 00 2 72322          DFAD    BUFF3,2                                             17090
02720 -0603 00 2 66112          DST     XDL,2           *IMPROVED SECOND SUM                17100
02721  0443 00 1 65706          DLD     XDD,1                                               17110
02722 -0603 00 2 66116          DST     XDL+4,2         *IMPROVED SECOND DERIVATIVE         17120
02723  0303 00 2 72326          DFSB    BUFF3+4,2                                           17130
02724 -0603 00 2 66120          DST     XDL+6,2         *IMPROVED FIRST DIFFERENCE          17140
02725  1 77776 1 02726          TXI     **1,1,-2                                            17150
02726  1 77734 2 02727          TXI     **1,2,-36                                           17160
02727  1 77772 1 02714          TXH     L62,1,-6                                            17170
02730  0020 00 0 02746    L64 TRA     L68             TRA REPLACED BY NOP FOR VAR. EQU.    17180
02731  0774 00 1 00000         AXT     0,1                                                 17190
02732  0443 00 1 66024    L65 DLD     V1DD,1                                              17200
02733  0301 00 2 72324          DFAC    BUFF3+2,2                                           17210
02734 -0603 00 2 66114          DST     XDL+2,2         *IMPROVED VAR. FIRST SUM            17220
02735  0301 00 2 72322          DFAD    BUFF3,2                                             17230
02736 -0603 00 2 66112          DST     XDL,2           *IMPROVED VAR. SECOND SUM           17240
02737  0443 00 1 66024          DLD     V1DD,1                                              17250
02740 -0603 00 2 66116          DST     XDL+4,2                                             17260
02741  0303 00 2 72326          DFSB    BUFF3+4,2                                           17270
02742 -0603 00 2 66120          DST     XDL+6,2         *IMPROVED VAR. FIRST DIFFERENCE     17280
02743  1 77776 1 02744          TXI     **1,1,-2                                            17290
02744  1 77734 2 02745          TXI     **1,2,-36                                           17300
02745  3 77734 1 02732          TXH     L65,1,-36                                           17310
                                •                                                           17320
02746  0535 00 1 03114    L68 LAC     2M,1                                                17330


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02747 -0634 00 1 02755          SXD     L70,1                                               17340
02750  0774 00 1 77776          AXT     -2,1                                                17350
02751  0443 00 1 66116    L69 DLD     XDL+4,1                                             17360
02752  0303 00 1 72326          DFSB    BUFF3+4,1                                           17370
02753 -0603 00 1 66120          DST     XDL+6,1                                             17380
02754  1 77776 1 02755          TXI     **1,1,-2                                            17390
02755  3 00000 1 02751    L70 TXH     L69,1,**        ** LOADED AT L68+1                  17400
02756 -0534 00 2 02755          LXD     L70,2                                               17410
02757  1 77734 2 02760          TXI     **1,2,-36                                           17420
02760 -0634 00 2 02755          SXD     L70,2                                               17430
02761  1 00000 1 02762    L72 TXI     **1,1,**        **=-(38-2M)                         17440
02762  3 00000 1 02751    L73 TXH     L69,1,**        ***=108 OR -756                     17450
                                •                                                           17460
02763  0500 00 0 65656    L80 CLA     DTAPE           DECREASE TAPE DUMPING FLAG          17470
02764 -0520 00 0 65656          NZT     DTAPE                                               17480
02765  0500 00 0 65652          CLA     M                                                   17490
02766  0402 00 0 04713          SUB     =1                                                  17500
02767  0601 00 0 65656          STO     DTAPE                                               17510
                                •                                                           17520
02770  0500 00 0 03105          CLA     CSAVE           INCREMENT STEP DOUBLING             17530
02771 -0100 00 0 02773          TNZ     **2             DERIVATIVE LOCATOR                  17540
02772  0500 00 0 03106          CLA     4M4                                                 17550
02773  0402 00 0 04714          SUB     =2                                                  17560
02774  0601 00 0 03105          STO     CSAVE                                               17570
                                •                       CYCLE                               17580
02775  0520 00 0 03104    L82 ZET     STPCHG                                              17590
02776  0020 00 0 03007          TRA     L95             IF STPCHG NON ZERO GO TEST IF READY TO  17600
                                •                       DOUBLE YET                          17610
                                •                                                           17620
02777  0774 00 1 00000    L85 AXT     0,1                                                 17630
03000  0535 00 2 03105          LAC     CSAVE,2         SAVE CURRENT SECOND DERIVATIVES     17640
03001  0443 00 1 66116    L90 DLD     XDL+4,1         IN BUFF                             17650
03002 -0603 00 2 67476          DST     BUFF,2                                              17660
03003  1 77734 1 03004          TXI     **1,1,-36                                           17670
03004  1 77674 2 03005          TXI     **1,2,-68                                           17680
03005  3 00000 1 03001    L92 TXH     L90,1,**        ***=108 OR -756                     17690
03006  0020 00 0 01753          TRA     TSTES*                                              17700
                                •                                                           17710
03007  0402 00 0 03114    L95 SUB     2M              TEST IF HAVE ENOUGH DERIVATIVES     17720
03010 -0100 00 0 02777          TNZ     L85             TO DOUBLE THE STEP.  IF SO          17730
03011  0600 00 0 03104          STZ     STPCHG          THEN STORE ZERO IN STPCHG           17740
03012  0020 00 0 02777          TRA     L85                                                 17750
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                        *                                                                  17770
                        *          ********************************                        17780
                        *                                                                  17790
                        *          SPECIAL MATRIX MULTIPLICATION SUBROUTINE TO COMPUTE     17800
                        *          SECOND DERIVATIVES FOR VARIATIONAL EQUATIONS.  ENTRY    17810
                        *          WITH COMINDEX OF CURRENT BV(1) IN X2 IS EXPECTED.       17820
                        *          THE ADDRESS OF THE COEFFICIENT MATRIX MUST              17830
                        *          BE PREVIOUSLY STORED IN MAT.  THEN                      17840
                        *                    TSX MATMPY,4                                  17850
                        *          RETURN IS TRA 1,4                                       17860

03013  0634 00 1 03056  MATMPY SXA     MX1,1                                              17870
03014  0634 00 2 03057        SXA     MX2,2                                              17880
03015  0634 00 4 03060        SXA     MX4,4                                              17890
03016  0634 00 2 03036        SXA     MM6,2                                              17900
03017  0774 00 4 00003        AXT     3,4                                                17910
03020  0634 00 4 03054    MM1 SXA     MM8,4                                              17920
03021  0774 00 1 77464        AXT     -204,1                                             17930
03022 -0634 00 1 03035        SXD     MM3,1                                              17940
03023  0534 00 2 03057        LXA     MX2,2                                              17950
03024  0774 00 1 00000    MM2 AXT     0,1             COMPUTE DDU=A*U WHERE              17960
03025  0600 00 0 03076        STZ     TEMP+12         A(3,3) AND U(3,6).  THE FIRST      17970
03026  0600 00 0 03077        STZ     TEMP+13         ROW OF DDU(3,6) IS COMPUTED FIRST  17980
03027  0443 00 1 03000    MAT DLC     **,1            ***ADDR. OF MATRIX                 17990
03030  0261 00 2 70056        DFMP    BV1,2                                              18000
03031  0301 00 0 03076        DFAD    TEMP+12                                            18010
03032 -0603 00 0 03076        DST     TEMP+12                                            18020
03033  1 77776 1 03034        TXI     **-1,1,-2                                          18030
03034  1 77674 2 03035        TXI     **-1,2,-68                                         18040
03035  3 00000 2 03027    MM3 TXH     MAT,2,**                                           18050

03036  0774 00 1 00000    MM6 AXT     **,1            ***INDEX OF ADDR. OF COMPUTED      18070
03037 -0603 00 1 70012        DST     BDV1,1          DERIVATIVE                         18080
03040  1 77464 1 03041        TXI     **+1,1,-204                                        18090
03041  0634 00 1 03036        SXA     MM6,1                                              18100
03042 -0534 00 1 03035        LXD     MM3,1                                              18110
03043  1 77464 1 03044        TXI     **+1,1,-204                                        18120
03044 -0634 00 1 03035        SXD     MM3,1                                              18130
03045  3 75470 2 03024        TXH     MM2,2,-1224                                        18140
03046  0534 00 1 03036        LXA     MM6,1           RESET DERIVATIVE STORAGE FOR       18150
03047  1 02204 1 03050        TXI     **+1,1,1156     NEXT ROW OF DDU                    18160
03050  0634 00 1 03036        SXA     MM6,1                                              18170
03051  0534 00 1 03027        LXA     MAT,1                                              18180


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03052  1 00006 1 03053        TXI     **+1,1,6                                           18190
03053  0634 00 1 03027        SXA     MAT,1           SET ADDR. OF NEXT ROW OF MATRIX    18200
03054  0774 00 4 00000    MM8 AXT     **,4                                               18210
03055  2 00001 4 03020        TIX     MM1,4,1                                            18220
03056  0774 00 1 00000    MX1 AXT     **,1                                               18230
03057  0774 00 2 00000    MX2 AXT     **,2                                               18240
03060  0774 00 4 00000    MX4 AXT     **,4                                               18250
03061  0020 00 4 00001        TXA     1,4                                                18260

                       065652 COMMON BCOL    65657                                      18280
                         65652       M EQU     COMMON                                   18290
                         65653       J EQU     M+1                                      18300
                         65654       N EQU     M+2                                      18310
                         65655  OPTION EQU     M+3                                      18320
                         65656   DTAPE EQU     M+4                                      18330
                         65657       S EQU     M+5                                      18340
                         65660      FS EQU     M+6                                      18350
                         65666       H EQU     M+12                                     18360
                         65670       T EQU     M+14                                     18370
                         65672       X EQU     M+16                                     18380
                         65674       Y EQU     M+18                                     18390
                         65676       Z EQU     M+20                                     18400
                         65700      XD EQU     M+22                                     18410
                         65702      YD EQU     M+24                                     18420
                         65704      ZD EQU     M+26                                     18430
                         65706     XDD EQU     M+28                                     18440
                         65710     YDD EQU     M+30                                     18450
                         65712     ZDD EQU     M+32                                     18460
                         65714      V1 EQU     M+34                                     18470
                         65756     V18 EQU     M+68                                     18480
                         65760     V19 EQU     M+70                                     18490
                         66024    V1DD EQU     M+106                                    18500
                         66070  MATRIX EQU     M+142                                    18510
                         66112     XDL EQU     M+160                                    18520
                         66156     YDL EQU     M+196                                    18530
                         66222     ZDL EQU     M+232                                    18540
                         66266    V1DL EQU     M+268                                    18550
                         67476    BUFF EQU     M+716                                    18560
                         67542      BX EQU     M+952                                    18570
                         67602     BD1 EQU     M+984                                    18580
                         67616     BD2 EQU     M+996                                    18590
                         67632     BD3 EQU     M+1008                                   18600
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      **FORTSZ**        MODIFIED BY C. LARSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 45

                 67646     HY EQU    *+1020                                              18610
                 67706   BUFF1 EQU    *+1152                                              18620
                 67756     BZ EQU    *+1098                                              18630
                 70012     FO EQU    *+1120                                              18640
                 70012   3DV1 EQU    *+1120                                              18650
                 70052   AVGL EQU    *+115.                                              18660
                 700.6    EV1 EQ     *+1156                                              18670
                 72322  BUFF2 EQU    *+2344                                              18680
                 72322  BUFF3 EQU    *+2344                                              18690
                 72364     BT EQU    *+2378                                              18700
                 72424      A EQU    *+2410                                              18710
                                                                                         18720
03062                    TEMP BSS     14                                                  18730
                 03072  TEMP8 EQU    TEMP+8                                              18740
03100                     HSL BSS     2                                                   18750
03102                     FMJ BSS     2                                                   18760
03104  0 00000 0 00000  STPCHG PZE                                                       18770
                 03104    STPSI EQU    STPCHG                                          18780
03105  0 00000 0 00000  CSAVE PZE                                                       18790
                 03105     TEST EQU    CSAVE                                           18800
03106  0 00000 0 00000  COUNT PZE                                                       18810
                 03106      4M4 EQU    COUNT                                           18820
03107  0 00000 0 00000    FLAG PZE                                                      18830
03110                    DEPSI BSS     1                                                 18840
                                                                                         18850
03111  0 00000 0 00000      M1 PZE                    =M+1                              18860
03112  0 00000 0 00000      M2 PZE                    =M+2                              18870
03113  0 00000 0 00000      M3 PZE                    =M+3                              18880
03114  0 00000 0 00000      2M PZE                    =2M                               18890
03115  0 00000 0 00000     2M2 PZE                    =2M+2                             18900
03116  0 00000 0 00000     2M6 PZE                    =2M+6                             18910
03117                       2MJ BSS     1                                               18920
03120                      2MN2 BSS     1                                               18930
03121 +0020000076100     TRANCP OCT     0320000076100                                   18940
03122 +2014000000000      LOG1  OCT     20140000000000,1460000000000          LOG1  1   18950
03123 +1460000000000                                                                     18960
03124 -2000000000000            OCT     60000000000000,5450000000000          LOG1  2   18970
03125 -1430000000000                                                                     18980
03126 -175525252525             OCT     57552525252 5,542252525253            LOG1  3   18990
03127 -142252525253                                                                      19000
03130 -174525252525             OCT     57452525252 5,541252525253            LOG1  4   19010
03131 -141252525253
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      **FORTSZ**        MODIFIED BY C. LARSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 46

03132 -173660266026             OCT     573660266026,540602660266             LOG1  5   19020
03133 -140602660266                                                                      19030
03134 -1734631465 4             OCT     5734o3146314,540631463146             LOG1  6   19040
03135 -140631463146                                                                      19050
03136 -172723445071             OCT     572723445071,53776,723445             LOG1  7   19060
03137 -137761723445                                                                      19070
03140 -172964471164             OCT     5725o4 71164,537371164371             LOG1  8   19080
03141 -137371164371                                                                      19090
03142 -172462460505             OCT     572462460505,337274452040             LOG1  9   19100
03143 -137274452040                                                                      19110
03144 -172402477052             OCT     572402477052,537565544603             LOG1 10   19120
03145 -137565544603                                                                      19130
03146 -171674557257             OCT     571e74557257,536023460747             LOG1 11   19140
03147 -136023460747                                                                      19150
03150 -171604172262             OCT     571604172262,536.47565543             LOG1 12   19160
03151 -136147565543                                                                      19170
03152 -171527142211             OCT     571527142211,536101546374             LOG1 13   19180
03153 -136101546374                                                                      19190
03154 -171462426632             OCT     571462426632,535573445503             LOG1 14   19200
03155 -135573445503                                                                      19210
03156 -171424166250             OCT     571424166250,536052351371             LOG1 15   19220
03157 -136052351371                                                                      19230
03160 -170765462703             OCT     570765462703,535321312561             LOG1 16   19240
03161 -135321312561                                                                      19250
03162 -170712317131             OCT     570712317131,535325634233             LOG1 17   19260
03163 -135525634233                                                                      19270
03164 -170645251150             OCT     570645251150,535272751156             LOG1 18   19280
03165 -135272751156                                                                      19290
03166 +2014000000000      PM1 OCT 20140000000,1460000000000 +.1000000000000000000D+01   PM1 -2
03167 +1460000000000                                                                     19300
03170 +0000000000000            OCT 00000000000,0000000000000 +.0000000000000000000D+00 PM1 -1
03171 +0000000000000                                                                     19310
03172 +175525252525             OCT 175525252525,142252525253 +.8333333333333333333D-01 PM1  0
03173 +142252525253                                                                      19320
03174 +175525252525             OCT 175525252525,142252525253 +.8333333333333333333D-01 PM1  1
03175 +142252525253                                                                      19330
03176 +175504210421             OCT 175504210421,142042104211 +.7916666666666666666D-01 PM1  2
03177 +142042104211                                                                      19340
03200 +175463146314             OCT 175463146314,142631463146 +.7499999999499999999D-01 PM1  3
03201 +142631463146                                                                      19350
03202 +175444167144             OCT 175444167144,142167144167 +.7134589947089970899D-01 PM1  4
03203 +142167144167
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      **FORTSZ**     MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 47
03204 +175427272727                OCT 175427272727,142272727273 +.68204365079365079365D 01   PM1  5
03205 +142272727273
03206 +175414212434                OCT 175414212434,142545004634 +.65495756172839506172D-01   PM1  6
03207 +142545004634
03210 +175402477052                OCT 175402477052,142565544603 +.63140432O9 7654320480-01   PM1  7
03211 +142565544603
03212 +174764235204                OCT 174764235204,141726027044 +.61072649861712361712D-01   PM1  8
03213 +141726027044
03214 +174745230736                OCT 174745230738,141601523074 +.59240564123376623376D-01   PM1  9
03215 +141601523074
03216 +174727707074                OCT . 727707074,141432254733 +.576036258574531357330-01   PM1 10
03217 +141432254733
03220 +174713642150                OCT 174713642150,141071270345 +.56129980884507174189D-01   PM1 11
03221 +141071270345
03222 +174700700221                OCT 174700700221,141104773324 +.54794379107071147139D-01   PM1 12
03223 +141104773324
03224 +174666714412                OCT 174666714412,141767161303 +.53576593744966381926D-01   PM1 13
03225 +141767161303
03226 +174655502164                OCT 1746556C2164,141040342421 +.52460247680248764811D-01   PM1 14
03227 +141C 0342421
03230 +174  251150                 OCT 174645251150,141272751156 +.51431942901177079223D-01   PM1 15
03231 +141272751156
03232 +201400000000          P0    OCT 201400000000,146000000000 +.10000000000000000000D+01   P0  -2
03233 +146000000000
03234 -201400000000                OCT 601400000000,546000000000 -.10000000000000000000D+01   P0  -1
03235 -146000000000
03236 +175525252525                OCT 175525252525,142252525253 +.83333333333333333333D-01   P0   0
03237 +142252525253
03240 +000000000000                OCT 000000000000,000000000000 -.71746481373430634031D-42   P0   1
03241 +000000000000
03242 -171421042104                OCT 571421042104,536210421042 -.41666666666666666666D-02   P0   2
03243 -136210421042
03244 -171421042104                OCT 571421042104,536210421042 -.41666666666666666666D-02   P0   3
03245 -136210421042
03246 -17 736746422                OCT 5.0736746422,535114736747 -.36541005291005291005D-02   P0   4
03247 -135114736747
03250 -170633610633                OCT 570633610633,535610633611 -.31415343915343915343D-02   P0   5
03251 -135610633611
03252 -170543013525                OCT 570543013525,535275121752 -.27086089065255731922D-02   P0   6
03253 -135275121752
03254 -170464557076                OCT 570464557076,535752001411 -.23553240740740740740D-02   P0   7
03255 -135752001411
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      **FORTSZ**     MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 48
03256 -170417016410                OCT 570417016410,535525447047 -.20677822370530 038640-02   P0   8
03257 -135525447047
03260 -167740212305                OCT 567740212305,534214176415 -.18320857383357382357--02   P0   9
03261 -134214176415
03262 -167655072106                OCT 567655072106,534352306044 -.16369382859234876430D-02   P0  10
03263 -134352306044
03264 -167602235216                 T 567602235216,53403 217  2 -.14736449529459615438D-02   P0  11
03265 -134037217302
03266 -167536075337                OCT 567536075337,534 13641034 -.13356017774360270502D-02   P0  12
03267 -134213641034
03270 -167477170304                OCT 567477170304,5 4670501037 -.12177852621047652132D-02   P0  13
03271 -134670501037
03272 -167444511335                OCT 567444511335,534330733076 -.11163460647176171146D-02   P0  14
03273 -134330733076
03274 -167415440566                OCT 567415440566,534257452131 -.10283047790716855883D-02   P0  15
03275 -134257452131
03276 +201400000000          P1    OCT 201400000000,146000000000 +.10000000000000000000D+01   P1  -2
03277 +146000000000
03300 -202400000000                OCT 602400000000,546000000000 -.20000000000000000000D+01   P1  -1
03301 -147000000000
03302 +201425252525                OCT 201425252525,146252525253 +.10833333333333333333D+01   P1   0
03303 +146252525253
03304 -175525252525                OCT 575525252525,542252525253 -.83333333333333333333D-01   P1   1
03305 -142252525253
03306 -171421042104                OCT 571421042104,536210421042 -.41666666666666666666D-02   P1   2
03307 -136210421042
03310 +000000000000                OCT 000000000000,000000000000 +.35873240686715317015D-42   P1   3
03311 +000000000000
03312 +166414566731                OCT 166414566731,133420414567 +.51256613756613756613D-03   P1   4
03313 +133420414567
03314 +166414566731                OCT 166414566731,133420414567 +.51256613756613756613D-03   P1   5
03315 +133420414567
03316 +165705751063                OCT 165705751063,132135116372 +.43292548500881834215D-03   P1   6
03317 +132135116372
03320 +165562344263                OCT 165562344263,132231203406 +.35328483245149911916D-03   P1   7
03321 +132231203406
03322 +165455404662                OCT 165455404662,132243323413 +.28754183702100368767D-03   P1   8
03323 +132243323413
03324 +165756225140                OCT 165756225140,131367175020 +.23569649871733200066D-03   P1   9
03325 +131367175020
03326 +164631201766                OCT 164631201766,131416703511 +.19514745241225069267D-03   P1  10
03327 +131416703511
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 49

03330 +164526346703            OCT 164526346703,131130665420 +.16329333297752609921D-03   P1  11
03331 +131130665420
03332 +164441376566            OCT 164441376566,131233562457 +.13804347550393449362D-03   P1  12
03333 +131233562457
03334 +163756120646            OCT 163756120646,130462777714 +.11781641573126183699D-03   P1  13
03335 +130462777714
03336 +163651357166            OCT 163651357166,130773137030 +.10143929738714809861D-03   P1  14
03337 +130773137030
03340 +163561213161            OCT 163561213161,130225417112 +.88041285645931524270-04    P1  15
03341 +130225417112
03342 +201400000000       P2   OCT 201400000000,146000000000 +.10000000000000000000D+01   P2  -2
03343 +146000000000
03344 -202600000000            OCT 602600000000,547000000000 -.30000000000000000000D+01   P2  -1
03345 -147000000000
03346 +202612525252            OCT 202612525252,147525252525 +.36833333333333333333D+01   P2   0
03347 +147525252525
03350 -201452525252            OCT 601452525252,546525252525 -.11666666666666666666D+01   P2   1
03351 -146525252525
03352 +175504210421            OCT 175504210421,142042104211 +.79166666666666666666D+01   P2   2
03353 +142042104211
03354 +171421042104            OCT 171421042104,136210421042 +.41666666666666666666D-02   P2   3
03355 +136210421042
03356 +166414566731            OCT 166414566731,133420414567 +.51256613756613756613D-03   P2   4
03357 +133420414567
03360 +000000000000            OCT 000000000000,000000000000 +.10761472206014595194D-41   P2   5
03361 +000000000000
03362 -163516022777            OCT 563516022777,530417453717 -.79640652557319223985D-04   P2   6
03363 -130417453717
03364 -163516022777            OCT 563516022777,530417453717 -.79640652557319223985D-04   P2   7
03365 -130417453717
03366 -163423576003            OCT 563423576003,530727277756 -.65742995430495430495D-04   P2   8
03367 -130727277756
03370 -162662722020            OCT 562662722020,527476250031 -.51845136303671537004D-04   P2   9
03371 -127476250031
03372 -162524116647            OCT 562524116647,527641345434 -.40049904630508135799D-04   P2  10
03373 -127641345434
03374 -162413154315            OCT 562413154315,527330070342 -.31854119434724593454D-04   P2  11
03375 -127330070342
03376 -161647501146            OCT 561647501146,526751027416 -.25250157467591605598D-04   P2  12
03377 -126751027416
03400 -161523262430            OCT 561523262430,526021625106 -.20226760178672656626D-04   P2  13
03401 -126021625106
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 50

03402 -161422606276            OCT 561422606276,526337203317 -.16377117944113738380D-04   P2  14
03403 -126337203317
03404 -160701440055            OCT 560701440055,525455177163 -.13398011712165723380-04    P2  15
03405 -125455177163
03406 +201400000000       P3   OCT 201400000000,146000000000 +.10000000000000000000D+01   P3  -2
03407 +146000000000
03410 -203400000000            OCT 603400000000,550000000000 -.40000000000000000000D+01   P3  -1
03411 -150000000000
03412 +203605252525            OCT 203605252525,150252525253 +.60833333333333333331D+01   P3   0
03413 +150252525253
03414 -203420000000            OCT 603420000000,550000000000 -.42499999999999999990D+01   P3   1
03415 -150000000000
03416 +201476735673            OCT 201476735673,146567356736 +.12458333333333333330D+01   P3   2
03417 +146557356736
03420 -175463146314            OCT 575463146314,542631463146 -.75000000000000000000D-01   P3   3
03421 -142631463146
03422 -170736746422            OCT 570736746422,535114736747 -.36541005291005291005D-02   P3   4
03423 -135114736747
03424 -166414566731            OCT 566414566731,533420414567 -.51256613756613756613D-03   P3   5
03425 -133420414567
03426 -163516022777            OCT 563516022777,530417453717 -.79640652557319223985D-04   P3   6
03427 -130417453717
03430 +000000000000            OCT 000000000000,000000000000 -.16142958309021892657D-41   P3   7
03431 +000000000000
03432 +160722247734            OCT 160722247734,125701537410 +.13897657126823793490D-04   P3   8
03433 +125701537410
03434 +160722247734            OCT 160722247734,125701537410 +.13897657126823793490D-04   P3   9
03435 +125701537410
03436 +160573024643            OCT 160573024643,125163411767 +.11296291998590279013D-04   P3  10
03437 +125163411767
03440 +160443601551            OCT 160443601551,125445264345 +.85949268703567645366D-05   P3  11
03441 +125445264345
03442 +157673136317            OCT 157673136317,124434545334 +.66039619671329878560D-05   P3  12
03443 +124434545334
03444 +157521072473            OCT 157521072473,124435011440 +.50233972889189489718D-05   P3  13
03445 +124435011440
03446 +157402260546            OCT 157402260546,124312106734 +.38496422365589182462D-05   P3  14
03447 +124312106734
03450 +156617662475            OCT 156617662475,123105036252 +.29791062028971660416D-05   P3  15
03451 +123105036252
03452 +201400000000       P4   OCT 201400000000,146000000000 +.10000000000000000000D+01   P4  -2
03453 +146000000000
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 51
03454 -203500000000           OCT 603400000050,550000000000 -.50J0000000C000000000D+C1   P4  -1
03455 -150000000000
03456 +204502525252           OCT 204502525252,151525252525 +.1008333333333333333330+02   P4   0
03457 +151525252525
  460 -204512525252           OCT 604512525252,551525252525 -.103333333333333333330+02   P4   1
03461 -151525252525
03462 +203537567356,150735673567 OCT 203537567356,150735673567 +.5495833333333333333330+01 P4  2
03463 +150735673567
03464 -201522104210           OCT 601522104210,546421042104 -.1320833333333333333330+01   P4   3
03465 -146421042104
03466 +175444167144,142167144167 OCT 175444167144,142167144167 +.713458994708994708990-01 P4  4
03467 +142167144167
03470 +170633610633,135610633611 OCT 170633610633,135610633611 +.3141534391534391534300-02 P4  5
03471 +135610633611
03472 +165705751063,132135116372 OCT 165705751063,132135116372 +.4329254850081834215D-03 P4  6
03473 +132135116372
03474 +163516022777,130417453717 OCT 163516022777,130417453717 +.7964065255731922398D-04 P4  7
03475 +130417453717
03476 +160722247734,125701537410 OCT 160722247734,125701537410 +.1389765712682379349D-04 P4  8
03477 +125701537410
03500 +000000000000           OCT C00000000000,000000000000 -.3228591661804378931D-41   P4  9
03501 +000000000000
03502 -156535114346,523470526105 OCT 556535114346,523470526105 -.2601365128233514476 D-05 P4 10
03503 -123470526105
03504 -156535114346,523470526105 OCT 556535114346,523470526105 -.2601365128233514476 D-05 P4 11
03505 -123470526105
03506 -156430512007,523134006736 OCT 556430512007,523134006736 -.2C9996490322377668050-05 P4 12
03507 -123134006736
03510 -155650217117,522376557357 OCT 555650217117,522376557357 -.1585564678214038884 2D-C5 P4 13
03511 -122376557357
03512 -155473047525,522113412417 OCT 555473047525,522113412417 -.1173755054360030725 5D-05 P4 14
03513 -122113412417
03514 -154723273076,521474676073 OCT 554723273076,521474676073 -.5705360316617522045 9D-C6 P4 15
03515 -121474676073
03516 +201400000000           P5 OCT 201400C0C000C,146000000000 +.1000000000000000000000D+C1 P5 -2
03517 +146000000000
03520 -203600000000           OCT 603600C00000C,550000000000 -.6000000000000000000000D+C1 P5 -1
03521 -150000000000
03522 +204742525252           OCT 204742525252,151525252525 +.1508333333333333333330+02   P5   0
03523 +151525252525
03524 -205506525252           OCT 605506525252,552525252525 -.2041666666666666666656D+C2 P5   1
03525 -152525252525
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 52
03526 +204772421042           OCT 204772421042,151104210421 +.1582916666666666666660+02   P5   2
03527 +151104210421
03530 -203664210421           OCT 603664210421,550042104211 -.6816666666666666666660+C1   P5   3
03531 -150042104211
03532 +201544313556           OCT 201544313556,146650410314 +.1392179232804232804200+01   P5   4
03533 +146650410314
03534 -175427272727           OCT 575427272727,542272727273 -.6620436507936509365D-01     P5   5
03535 -142272727273
03536 -170563013525           OCT 570563013525,535275121752 -.2708608906525573192200-02   P5   6
03537 -135275121752
03540 -165562344263           OCT 565562344263,532231203406 -.3532848324514991181600-03   P5   7
03541 -132231203406
03542 -163423576003           OCT 563423576003,530727277756 -.6574299543049543049500-04   P5   8
03543 -130727277756
03544 -160722247734           OCT 560722247734,525701537410 -.1389765712682379349000-04   P5   9
03545 -125701537410
03546 -156535114346           OCT 556535114346,523470526105 -.2601365128233514476900-05   P5  10
03547 -123470526105
03550 +000000000000           OCT 000000000000,000000000000 -.9865141188466712179300-42   P5  11
03551 +000000000000
03552 +154422011575,121562474634 OCT 154422011575,121562474634 +.5104002250097377963300-06 P5 12
03553 +121562474634
03554 +154422011575,121562474634 OCT 154422011575,121562474634 +.5104002250097377963300-06 P5 13
03555 +121562474634
03556 +153664635751,120314623577 OCT 153664635751,120314623577 +.4068056239540081586500-06 P5 14
03557 +120314623577
03560 +153505450327,120264255705 OCT 153505450327,120264255705 +.3032190226982785209700-06 P5 15
03561 +120264255705
03562 +201400000000           P6 OCT 201400C00000,146000000000 +.1000000000000000000000+01 P6 -2
03563 +146000000000
03564 -203700000000           OCT 603700C00000,550000000000 -.7000000000000000000000D+C1   P6  -1
03565 -150000000000
03566 +205521252525,152252525253 OCT 205521252525,152252525253 +.2108333333333333333330+02 P6  0
03567 +152252525253
03570 -206434000000           OCT 606434000000,553000000000 -.3549999999999999999990+02   P6   1
03571 -153000000000
03572 +206441756735,153673567357 OCT 206441756735,153673567357 +.3624583333333333333330+02 P6  2
03573 +153673567357
03574 -205552252525,552252525253 OCT 605552252525,552252525253 -.2264583333333333333330+02 P6  3
03575 -152252525253
03576 +204406535566,151304103136 OCT 204406535566,151304103136 +.8208845899470899470800+01 P6  4
03577 +151304103136
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 53

03600 -2015656673l4              OCT 6015656673l4,5462045456b7 -.1460383597883597883350+01   P6   5
03601 -1462045456b7
03602 +1754142126j4              OCT 1754142126j4,1425455046j4 +.6549575617283950617200-01   P6   6
03603 +1425455046j4
03604 +1704645570l4              OCT 1704645570l4,1357520014ll +.2355324074074074074000-02   P6   7
03605 +1357520014ll
03606 +1454554046o2              OCT 1454554046o2,1322433234l3 +.2875418370210036876300-03   P6   8
03607 +1322433234l3
03610 +1626627220j0              OCT 1626627220j0,1274762500j1 +.9184533830367163700400-04   P6   9
03611 +1274762500j1
03612 +1605730246l3              OCT 1605730246l3,1251634117l7 +.1129629199859027901300-04   P6  10
03613 +1251634117l7
03614 +1565351143l6              OCT 1565351143l6,1234705261l5 +.2601365128233514476900-05   P6  11
03615 +1234705261l5
03616 +1544220115l5              OCT 1544220115l5,1215624746j4 +.5104002250097377963300-06   P6  12
03617 +1215624746j4
03620 +0000000000l0              OCT 0000000000l0,0000000000l0 -.4484155085839414626900-41   P6  13
03621 +0000000000l0
03622 -1516747261l0              OCT 5516747261l0,5161416273l6 -.1035906011557296376700-06   P6  14
03623 -1161416273l6
03624 -1516747261l0              OCT 5516747261l0,5161416273l6 -.1035906011557296376700-06   P6  15
03625 -1161416273l6
03626 +2014000000l0        P7    OCT 2014000000l0,1460000000l0 +.1000000000000000000000+01   P7  -2
03627 +1460000000l0
03630 -2044000000l0              OCT 6044000000l0,5510000000l0 -.8000000000000000000000+01   P7  -1
03631 -1510000000l0
03632 +2057012525j5              OCT 2057012525j5,1522525252j3 +.2222833333333333333330+02   P7   0
03633 +1522525252j3
03634 -2067045252j2              OCT 6067045252j2,5535252525j5 -.5658333333333333333330+02   P7   1
03635 -1535252525j5
03636 +2074367673j6              OCT 2074367673j6,2547356735j7 +.7174583333333333333330+02   P7   2
03637 +1547356735j7
03640 -2067271242l0              OCT 6067271242l0,5534210421l4 -.5889166666666666666660+02   P7   3
03641 -1534210421l4
03642 +2057555314l0              OCT 2057555314l0,1524145667j2 +.3085467923280423280400+02   P7   4
03643 +1524145667j2
03644 -2044653245l7              OCT 6044653245l7,5517245177j5 -.5669229497354497354400+01   P7   5
03645 -1517245177j5
03646 +2016065000j6              OCT 2016065000j6,1440324061j1 +.1525879534056437589700+01   P7   6
03647 +1440324061j1
03650 -1754024770j2              OCT 5754024770j2,5425655446j3 -.6314043209876543209800-01   P7   7
03651 -1425655446j3

      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 54

03652 -1724170164l0              OCT 5704170164l0,5355254470l7 -.2067782237053070386400-02   P7   8
03653 -1355254470l7
03654 -1647562251l0              OCT 5647562271l0,5313671750l0 -.2356964987173320506600-03   P7   9
03655 -1313671750l0
03656 -1625241146l7              OCT 5625241146l7,5276413454j4 -.4054904630508135799100-04   P7  10
03657 -1276413454j4
03660 -1604436015l1              OCT 5604436015l1,5254452643j5 -.8694926870356700453660-05   P7  11
03661 -1254452643j5
03662 -1564305120l7              OCT 5564305120l7,5231340067j6 -.2090964903223776680500-05   P7  12
03663 -1231340067j6
03664 -1544220115l5              OCT 5544220115l5,5215624746j4 -.5104002250097377963300-06   P7  13
03665 -1215624746j4
03666 -1516747261l0              OCT 5516747261l0,5161416273l6 -.1035906011557296376700-06   P7  14
03667 -1161416273l6
03670 +0000000000l0              OCT 0000000000l0,0000000000l0 -.2107552890344524874600-40   P7  15
03671 +0000000000l0
03672 +2014000000l0        P8    OCT 2014000000l0,1460000000l0 +.1000000000000000000000+01   P8  -2
03673 +1460000000l0
03674 -2044000000l0              OCT 6044000000l0,5510000000l0 -.9000000000000000000000+01   P8  -1
03675 -1510000000l0
03676 +2064405252j2              OCT 2064405252j2,1535252525j5 +.3608333333333333333330+02   P8   0
03677 +1535252525j5
03700 -2075225252j2              OCT 6075225252j2,5545252525j5 -.8456666666666666666660+02   P8   1
03701 -1545252525j5
03702 +2104005210j2              OCT 2104005210j2,1551042104j1 +.1283291666666666666660+03   P8   2
03703 +1551042104j1
03704 -2104052146j1              OCT 5104052146j1,5554631463l5 -.1306374999999999999990+03   P8   3
03705 -1554631463l5
03706 +2075467704l0              OCT 2075467704l0,1543135566j1 +.8974634589947069947000+02   P8   4
03707 +1543135566j1
03710 -2065041417j4              OCT 6065041417j4,5531734172j2 -.4052390873015073015800+02   P8   5
03711 -1531734172j2
03712 +2045461745j3              OCT 2045461745j3,1515277605j7 +.1119510885141093447400+02   P8   6
03713 +1515277605j7
03714 -2016266240l0              OCT 6016266240l0,5465616743j1 -.1589019786155202821800+01   P8   7
03715 -1465616743j1
03716 +1747642352j4              OCT 1747642352j4,1417260270j4 +.6107264984171236172200-01   P8   8
03717 +1417260270j4
03720 +1677402123j5              OCT 1677402123j5,1342141764l5 +.1332085736335738335700-02   P8   9
03721 +1342141764l5
03722 +1646312017j6              OCT 1646312017j6,1314167035l1 +.1951474524122506926700-03   P8  10
03723 +1314167035l1
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      **FORTSZ**      MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 55

03724 +162413154315           OCT 162413154315,127330070342 +.31254119434724593456D-04  P8  11
03725 +127330070342
03726 +157673136317           OCT 157673136317,124434545334 +.66039619671329878569D-05  P8  12
03727 +124434545334
03730 +155650217117           OCT 155650217117,122376557357 +.15905646782140388842D-05  P8  13
03731 +122376557357
03732 +153664635751           OCT 153664635751,120314623577 +.40458096238540081586SD-06  P8  14
03733 +120314623577
03734 +151674726110           OCT 151674726110,116141627346 +.10359060115572963767D-06  P8  15
03735 +116141627346
03736 +201400000000       P9  OCT 201400000000,146000000000 +.10000000000000000000D+01  P9  -2
03737 +146000000000
03740 -204500000000           OCT 604500000000,551000000000 -.10000000000000000000D+02  P9  -1
03741 -151000000000
03742 +206550525252           OCT 206550525252,153525252525 +.45083333333333333333D+02  P9   0
03743 +153525252525
03744 -207743000000           OCT 607743000000,554000000000 -.12074999999999999990D+03  P9   1
03745 -154000000000
03746 +210651773567           OCT 210651773567,155356735674 +.21299583333333333333D+03  P9   2
03747 +155356735674
03750 -211402756735           OCT 611402756735,556673567357 -.25896666666666666666D+03  P9   3
03751 -156673567357
03752 +210670611035           OCT 210670611035,155631035631 +.22038784509947089947D+03  P9   4
03753 +155631035631
03754 -210404424573           OCT 610404424573,555204573205 -.13027025462962962962D+03  P9   5
03755 -155204573205
03756 +206635601061           OCT 206635601061,153121413472 +.51719017581569864902D+02  P9   6
03757 +153121413472
03760 -204631057123           OCT 604631057123,551606150174 -.12784128637566137565D+02  P9   7
03761 -151606150174
03762 +201646330724           OCT 201646330724,146703435132 +.16550924360169151835D+01  P9   8
03763 +146703435132
03764 -174745230736           OCT 574745230736,541601523074 -.59240504123376623376D-01  P9   9
03765 -141601523074
03766 -167655072106           OCT 567655072106,534352305044 -.16369382859234876430D-02  P9  10
03767 -134352306044
03770 -164526346703           OCT 564526346703,531130665420 -.16329133297752699921D-03  P9  11
03771 -131130665420
03772 -161647501146           OCT 561647501146,526751027416 -.25250157467591605598D-04  P9  12
03773 -126751027416
03774 -157521072473           OCT 557521072473,524535011440 -.50233972889139489718D-05  P9  13
03775 -124535011440


      **FORTSZ**      MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 56

03776 -155473047525           OCT 555473047525,522113412417 -.11737550543600307255D-05  P9  14
03777 -122113412417
04000 -153505450327           OCT 553505450327,520264255705 -.30321902269827152097D-06  P9  15
04001 -120264255705
04002 +201400000000      P10  OCT 201400000000,146000000000 +.10000000000000000000D+01  P10 -2
04003 +146000000000
04004 -204540000000           OCT 604540000000,551000000000 -.11000000000000000000D+02  P10 -1
04005 -151000000000
04006 +206670525252           OCT 206670525252,153525252525 +.55083333333333333333D+02  P10  0
04007 +153525252525
04010 -210513525252           OCT 610513525252,555525252525 -.16583333333333333333D+03  P10  1
04011 -155525252525
04012 +211515575673           OCT 211515575673,156567356736 +.33374583333333333333D+03  P10  2
04013 +156567356736
04014 -211727754631           OCT 611727754631,556463146315 -.47196249999999999999D+03  P10  3
04015 -156463146315
04016 +211737263354           OCT 211737263354,156610206273 +.47935051256617566130D+03  P10  4
04017 +156610206273
04020 -211536516714           OCT 611536516714,556416714417 -.35065410052710052910D+03  P10  5
04021 -156416714417
04022 +210553765007           OCT 210553765007,155431076123 +.18198927221199294530D+03  P10  6
04023 +155431076123
04024 -207402306342           OCT 607402306343,554031422654 -.64503146219135802469D+02  P10  7
04025 -154031422654
04026 +204715712216           OCT 204715712216,151276213707 +.14432210735830527490D+02  P10  8
04027 +151276213707
04030 -201665455543           OCT 601665455543,546654467614 -.17093330001402918069D+01  P10  9
04031 -146654467614
04032 +174727707074           OCT 174727707074,141432254733 +.57603625837453135733D-01  P10 10
04033 +141432254733
04034 +167602235216           OCT 167602235216,134037217302 +.14736449529459615438D-02  P10 11
04035 +134037217302
04036 +.144441376566          OCT 144441376566,131233562457 +.13904317550993447362D-03  P10 12
04037 +131233562457
04040 +161523262430           OCT 161523262430,126021625106 +.20226760178672656260D-04  P10 13
04041 +126021625106
04042 +157402260546           OCT 157402260546,124312106734 +.38496422345589182462D-05  P10 14
04043 +124312106734
04044 +154723273076           OCT 154723273076,121474676073 +.87053603166175220459D-06  P10 15
04045 +121474676073
04046 +201400000000      P11  OCT 201400000000,146000000000 +.10000000000000000000D+01  P11 -2
04047 +146000000000
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 57

04050 -2046000000000          OCT 6046C00C0000,551000000000 -.1200000000000000000000D+02  P11 -1
04051 -151000000000
04052 +207410252577           OCT 207410252525,154252525253 +.[illegible]333333333333333333D+02  P11  0
04053 +154252525253
04054 -2106716525_5           OCT 61067165252[illegible],555252525253 -.2209166666666666666666D+03  P11  1
04055 -155252525253
04056 +211763450421           OCT 211763450421,156042104211 +.4995791666666666666666D+05  P11
04057 +156042104211
04060 -212422665252           OCT 212422665252,557525252525 -.6C570833333333333333D+03  P11  3
04061 -157525252525
04062 +212733520103           OCT 212733520103,157135566304 +.95121301259[illegible]37566130+03  P11  4
04063 +157135566304
04064 -212637001134           OCT 212637001134,557513451345 -.8300046130952380952300+03  P11  5
04065 -157513451345
04066 +212412244550           OCT 212412244550,157115565634 +.5326433727402999236300+03  P11  6
04067 +157115565634
04070  2107547701?1           OCT 210754770171,555045707451 -.2464924184303350970000+03  P11  7
04071 -155045707451
04072 +207473577564           OCT 207473577564,154661244245 +.7893736729271885521800+02  P11  8
04073 +154661244245
04074 -205402227775           OCT 205402227775,552331731334 -.1614355407372334456D+02  P11  9
04075 -152331731334
04076 +201704253725           OCT 201704253725,146565335133 +.1766936625977744942600+01  P11 10
04077 +146565335133
04100 -174713642150           OCT 5747,3642150,541071270345 -.5612998088450717418900-01  P11 11
04101 -141071270345
04102 -167536075337           OCT 567536075337,534213641034 -.13356C1777436027050200-02  P11 12
04103 -134213641034
04104 -163756120646           OCT 563756120646,534624777714 -.1178164153312618369900-03  P11 13
04105 -130462777714
04106 -161422606276           OCT 561422606276,526337203317 -.1637711794411373838000-04  P11 14
04107 -126337203317
04110 -156617662475           OCT 556617662475,523105036252 -.29791C6202897716604160-05  P11 15
04111 -123105036252
04112 +201400003000        P12 OCT 2014000C0000,146000000000 +.1000000000000000000000D+01  P12 -2
04113 +146000000000
04114 -204640000000           OCT 6046400C0000,551000000000 -.1300000000000000000000D+02  P12 -1
04115 -151000000000
04116 +207470252525           OCT 207473252525,154252525253 +.7808333333333333333330+02  P12  0
04117 +154252525253
04120 -211437000000           OCT 611437000000,556000000000 -.2869999999999999999990+03  P12  1
04121 -156000000000
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964        7/06/64     PAGE 58

04122 +212550176735           OCT 212550176735,157673567357 +.72C4958333333333333330+03  P12  2
04123 +157673567357
04124 -213506244631           OCT 6135C6244631,560463146315 -.1305287499999999999900+04  P12  3
04125 -160463146315
04126 +213667202566           OCT 213667202566,160731420415 +.1757021345899470899450+04  P12  4
04127 +160731420415
04130 -213675250517           OCT 613675250517,56C724517725 -.1781317625661375661300+04  P12  5
04131 -160724517725
04132 +213524522742           OCT 213524522742,160314517501 +.1362647985855379188D+0+  P12  6
04133 +160314517501
04134 -212605442606           OCT 6126C5442606,557327147547 -.7791357911706349206300+03  P12  7
04135 -157327147547
04136 +211505334031           OCT 211505334031,156577214676 +.3254297857230539522200+03  P12  8
04137 +156577214676
04140 -207574245564           OCT 607574245564,554147632534 -.9508092136644219977500+02  P12  9
04141 -154147632534
04142 +205436442572           OCT 205436442572,152621207202 +.1791049C67970108949300+02  P12 10
04143 +152621207202
04144 -201722550770           OCT 601722550770,546767162742 -.1823056606862252116800+01  P12 11
04145 -146767162742
04146 +174700700221           OCT 174700700221,141104773324 +.5479437910707114713900-01  P12 12
04147 +141104773324
04150 +167477170304           OCT 167477170304,134670501037 +.1211785362104765213200-02  P12 13
04151 +134670501037
04152 +163651357166           OCT 163651357166,130773137030 +.1014392973871480986100-03  P12 14
04153 +130773137030
04154 +160701440055           OCT 160701440055,125455177163 +.1339801174121657233800-04  P12 15
04155 +125455177163
04156 +201400000000        P13 OCT 2014C0000000,146000000000 +.1000000000000000000000D+01  P13 -2
04157 +146000000000
04160 -204700000000           OCT 6047C0000000,551000000000 -.1400000000000000000000D+02  P13 -1
04161 -151000000000
04162 +207554252525           OCT 207554252525,154252525253 +.9108333333333333333330+02  P13  0
04163 +154252525253
04164 -211555052525           OCT 611555052525,556252525253 -.3650833333333333333330+03  P13  1
04165 -156252525253
04166 +212767576735           OCT 212767576735,157673567357 +.1007495833333333333330+04  P13  2
04167 +157673567357
04170 -213772344210           OCT 613772344210,56C421042104 -.2025783333333333333330+04  P13  3
04171 -160421042104
04172 +214576623610           OCT 214576623610,161206273355 +.3062308845899470899400+0   P13  4
04173 +161206273335
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      **FORTS2**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 59

04174 -2146722255431          OCT 6146722255431,561327C6014[ -.353833e9715608465808D+0[  P13  5
04175 -161327060161
04176 +2146107756311          OCT 2146107756311,1611205517613 +.3143965611496715580?0+04  P13  6
04177 +161120517613
04200 -2144135621?2           OCT 6144135621?2,5616341015?2 -.2141783777?0C617283950+04  P13  7
04201 -161634101572
04202 +2134241103?1           OCT 2134241103?1,1603133?7?43 +.1104565576893688872?D+04  P13  8
04203 +160513327043
04204 -2116444053?6           OCT e116444C53?6,55e631163425 -.42C5107073?89496151990?03  P13  9
04205 -156631163425
04206 +2077037563?2           OCT 2077C3756322,154714074375 +.1129914120661432892?D+03  P13 10
04207 +154714074373
04210 -2054735712?2           OCT 6054735712?2,552260556340 -.19733557306563341615D+02  P13 11
04211 -152260556340
04212 +2017405667?5           OCT 2017405667?5,146411302631 +.1877860985969323264CD+01  P13 12
04213 +146411302631
04214 -1746667144?2           OCT 5746667144?2,541767161303 -.5357659374496638192?D-01  P13 13
04215 -141767161303
04216 -1674445113?5           OCT 5674445113?5,534330733076 -.1116346064717617114?D-02  P13 14
04217 -133330733076
04220 -1635612131?1           OCT 5635612131?1,530225417112 -.8804126564593152627?D-04  P13 15
04221 -130225417112
04222 +2014CCCC0000      P14  OCT 2014C0C00000,14e030000000 +.1000000000000000000D+01  P14 -2
04223 +14e000002000
04224 -2047400000000          OCT 6047400000000,551000000000 -.1500000000000000000D+02  P14 -1
04225 -151000000000
04226 +2077644252525          OCT 2077644252525,154252525253 +.1050833333333333333D+03  P14  0
04227 +154252525253
04230 -2117101252?2           OCT e117101252?2,556525252525 -.4561666666666666666D+03  P14  1
04231 -156525252525
04232 +2135271121?4           OCT 2135271121?4,1602104210?2 +.1372579166666666666D+04  P14  2
04233 +160210421042
04234 -2145?3121673           OCT 6145?3121673,561567356736 -.3033279166666666666D+04  P14  3
04235 -161567356736
04236 -2154760027?6           OCT 2154760027?6,162207346207 +.5088092179232804232?D+04  P14  4
04237 +162207346207
04240 -2156?4?4?4565          OCT 6156?4?4?4565,562656565657 -.6600647817460317460?D+04  P14  5
04241 -162656565657
04242 +2156415115?6           OCT 21?64151157e,1622?3677776 +.6682304533057760141?D+04  P14  6
04243 +162223677776
04244 -2155122677e5           OCT 2155122677e5,562766310602 -.5285769388503?864197D+04  P14  7
04245 -16276e310602
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      **FORTS2**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 60

04246 +2146256202?7           OCT 21?625620?67,161501655213 +.3?463493538998617123D+04  P14  8
04247 +161501655213
04250 -2135752116?7           OCT 6135752116?7,56C261563750 -.152507628398318502?8D+04  P14  9
04251 -160261563750
04252 +2124126004?5           OCT 2124126004?5,157606101252 +.5335021131556394412?D+03  P14 10
04253 +157606101252
04254 -2104113462?4           OCT 6104113462?4,55557411-032 -.1327249693727066308?0+03  P14 11
04255 -155574114032
04256 +2055316205?2           OCT 2055316205?2,152141232472 +.2161141?29253266488?D+02  P14 12
04257 +152141232472
04260 -2017563453?5           OCT 6017563453?5,546671066257 -.193.437579714289645?D+01  P14 13
04261 -146671066257
04262 +1746556021?4           OCT 1?46556021?4,141040342421 +.5246024768024876481?D-01  P14 14
04263 +141040342421
04264 +1674154405?6           OCT 1e7415440566,134257452131 +.1028304779071685588?D-02  P14 15
04265 +134257452131
04266 +20140000          P15  OCT 2014C0000000,1460000C0000 +.1000000000000000000D+01  P15 -2
04267 +146000C00000
04270 -2054000000000          OCT 6054CC000000,552000000000 -.1600000000000000000D+02  P15 -1
04271 -152000000000
04272 +2077402525?5           OCT 2077402525?5,154252525253 +.1200833333333333333D+03  P15  0
04273 +154252525253
04274 -2124305000?0           OCT 6124305000?0,557000000000 -.5612499999999999999D+03  P15  1
04275 -157000000000
04276 +2137111373?6           OCT 2137111373?6,160735673567 +.1828745833333333333D+04  P15  2
04277 +160735673567
04300 -2154232733?6           OCT 6154232733?6,562735671567 -.4405858333333333333D+04  P15  3
04301 -162735673567
04302 +2157734537?4           OCT 2157734537?4,162103135566 +.8121371345899470899?D+04  P15  4
04303 +162103135566
04304 -2165552136?6           OCT 6165552136?6,563033056033 -.1168873999669312169?D+05  P15  5
04305 -163033056033
04306 +2166370571?2           OCT 2166370571?2,163061232726 +.1328295240051807760?D+05  P15  6
04307 +163041232726
04310 -2165660006?2           OCT 6165660006?2,563105104300 -.1196805397158084656?D+05  P15  7
04311 -163105104300
04312 +2164125014?0           OCT 2164125014?0,163713517544 +.8532098742402948132?D+04  P15  8
04313 +163713517544
04314 -2154521554?9           OCT 6154521554?5,562515263500 -.4771425637883044673?2D+04  P15  9
04315 -162515263500
04316 +2144312450?1           OCT 2144C1245011,161072312237 +.2058578403138824466?D+04  P15 10
04317 +161072312237
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 61

04320 -2125115072104          OCT 212515072104,255774512426I -.6662270885283460721610+03   PI5 11
04321 -157745124261
04322 +210466530354           OCT 210466530354,155010237302 +.1543363376652392957770+03   PI5 12
04323 +155010237302
04324 -205570537046           OCT 205570537046,552434676005 -.2354285587224695452610+02   PI5 13
04325 -152434676005
04326 +201773701351           OCT 201773701351,146372075330 +.1788E978273V+53841070+01    PI5 14
04327 +146372075330
04330 -174645251150           OCT 574645251150,541272751156 -.51431 479011779792230-01    PI5 15
04331 -141272751156
04332 +200400000000      PH1  OCT 200400000000,145000000003 +.5000000000000000000D+00   PH1  1
04333 +145000000000
04334 +176400000000           OCT 176400000000,143000000000 +.1250000000000000000D+00   PH1  2
04335 +143000000000
04336 +175400000000           OCT 175400000000,142000000003 +.6250000000000000000D-01   PH1  3
04337 +142000000000
04340 +174500000000           OCT 174500000000,141000000000 +.3906250000000000000D-01   PH1  4
04341 +141000000000
04342 +173700000000           OCT 173700000000,140000000000 +.2734375000000000000D-01   PH1  5
04343 +140000000000
04344 +173520000000           OCT 173520000000,140000000000 +.2050781250000000000D-01   PH1  6
04345 +140000000000
04346 +173410000000           OCT 173410000000,140000000000 +.1611328125000000000D-01   PH1  7
04347 +140000000000
04350 +172655000000           OCT 172655000000,137000000000 +.1309204101562500000D-01   PH1  8
04351 +137000000000
04352 +172545400000           OCT 172545400000,137000000000 +.1091003417968750000D-01   PH1  9
04353 +137000000000
04354 +172457700000           OCT 172457700000,137000000000 +.9273529052734375000D-02   PH1 10
04355 +137000000000
04356 +172406340000           OCT 172406340000,137000000000 +.8008956990179687500D-02   PH1 11
04357 +137000000000
04360 +171713210000           OCT 171713210000,136000000000 +.7007837295532226562500-02  PH1 12
04361 +136000000000
04362 +171626214000           OCT 171626214000,136000000000 +.6199240684650927734370-02  PH1 13
04363 +136000000000
04364 +171552575000           OCT 171552575000,136000000000 +.5535036325454-7119140D-02  PH1 14
04365 +136000000000
04366 +171506360400           OCT 171506360400,136000000000 +.4981532409290924C7226D-02  PH1 15
04367 +136000000000
04370 +177400000000      PH2  OCT 177400000000,144000000000 +.2500000000000000000000D+00  PH2  2
04371 +144000000000
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 62

04372 +176400000000           OCT 176400000000,143000000000 +.1250000000000000000000D+00  PH2  3
04373 +143000000000
04374 +175500000000           OCT 175500000000,142000000000 +.7812500000000000000000D-01  PH2  4
04375 +142000000000
04376 +174700000000           OCT 174700000000,141000000000 +.5468750000000000000000D-01  PH2  5
04377 +141000000000
04400 +174520000000           OCT 174520000000,141000000000 +.4101562500000000000000D-01  PH2  6
04401 +141000000000
04402 +174410000000           OCT 174410000000,141000000000 +.3222656250000000000000D-01  PH2  7
04403 +141000000000
04404 +173655000000           OCT 173655000000,140000000000 +.2618406203125000000000D-01  PH2  8
04405 +140000000000
04406 +173545400000           OCT 173545400000,140000000000 +.2182006835937500000000D-01  PH2  9
04407 +140000000000
04410 +173457700000           OCT 173457700000,140000000000 +.1854705810546875000000D-01  PH2 10
04411 +140000000000
04412 +173406340000           OCT 173406340000,140000000000 +.1601791381835937500000D-01  PH2 11
04413 +140000000000
04414 +172713210000           OCT 1.2713210000,137000000000 +.1401567459106445312500-01   PH2 12
04415 +137000000000
04416 +172626214000           OCT 172626214000,137000000000 +.1239 8481369018554687D-01   PH2 13
04417 +137000000000
04420 +172552575000           OCT 172552575000,137000000000 +.1107007265090942382800-01   PH2 14
04421 +137000000000
04422 +172506360400           OCT 172506360400,137000000000 +.9963065385818481445300-02   PH2 15
04423 +137000000000
04424 +176400000000      PH3  OCT 176400000000,143000000000 +.1250000000000000000000D+00  PH3  3
04425 +143000000000
04426 +175600000000           OCT 175600000000,142000000000 +.9375000000000000000000D-01  PH3  4
04427 +142000000000
04430 +175440000000           OCT 175440000000,142000000000 +.7031250000000000000000D-01  PH3  5
04431 +142000000000
04432 +174760000000           OCT 17 760000000,141000000000 +.5468750000000000000000D-01  PH3  6
04433 +141000000000
04434 +174550000000           OCT 174550000000,141000000000 +.4394531250000000000000D-01  PH3  7
04435 +141000000000
04436 +174451000000           OCT 174451000000,141000000000 +.3625488281250000000000D-01  PH3  8
04437 +141000000000
04440 +173764400000           OCT 173764400000,140000000000 +.3054809570312500000000D-01  PH3  9
04441 +140000000000
04442 +173655000000           OCT 173655000000,140000000000 +.2618408203125000000000D-01  PH3 10
04443 +140000000000
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 63

04444 +173564740000            OCT 173564740000,140000000000 +.22762298583984375000D-01  PH3  11
04445 +140000000000
04446 +173510030000            OCT 173510030000,140000000000 +.20022392272949218750D-01  PH3  12
04447 +140000000000
04450 +173443352000            OCT 173443352000,140000000000 +.17789125442504882812D-01  PH3  13
04451 +140000000000
04452 +173405132000            OCT 173405132000,140000000000 +.15940904617309570312D-01  PH3  14
04453 +140000000000
04454 +172727442400            OCT 172727442400,137000000000 +.14391094446182230976D-01  PH3  15
04455  137000000000
04456 +175400000000      PH4   OCT 175400000000,142000000000 +.62500000000000000000D-01  PH4   4
04457 +142000000000
04460 +175400000000            OCT 175400000000,142000000000 +.62500000000000000000D-01  PH4   5
04461 +142000000000
04462 +174700000000            OCT 174700000000,141000000000 +.56687500000000000000D-01  PH4   6
04463 +141000000000
04464 +174600000000            OCT 174600000000,141000000000 +.46875000000000000000D-01  PH4   7
04465 +141000000000
04466 +174512000000            OCT 174512000000,141000000000 +.40283203125000000000D-01  PH4   8
04467 +141000000000
04470 +174436000000            OCT 174436000000,141000000000 +.34912109375000000000D-01  PH4   9
04471 +141000000000
04472 +173764400000            OCT 173764400000,140000000000 +.30548095703125000000D-01  PH4  10
04473 +140000000000
04474 +173672000000            OCT 173672000000,140000000000 +.26977539062500000000D-01  PH4  11
04475 +140000000000
04476 +173611520000            OCT 173611520000,140000000000 +.24026870727539062500D-01  PH4  12
04477 +140000000000
04500 +173541220000            OCT 173541220000,140000000000 +.21562576293945312500D-01  PH4  13
04501 +140000000000
04502 +173477156000            OCT 173477156000,140000000000 +.19483327865600585937D-01  PH4  14
04503 +140000000000
04504 +173442144000            OCT 173442144000,140000000000 +.17712116241455078125D-01  PH4  15
04505 +140000000000
04506 +174400000000      PH5   OCT 174400000000,141000000000 +.31250000000000000000D-01  PH5   5
04507 +141000000000
04510 +174500000000            OCT 174500000000,141000000000 +.39062500000000000000D-01  PH5   6
04511 +141000000000
04512 +174500000000            OCT 174500000000,141000000000 +.39062500000000000000D-01  PH5   7
04513 +141000000000
04514 +174454000000            OCT 174454000000,141000000000 +.36621093750000000000D-01  PH5   8
04515 +141000000000
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      **FORTSZ**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 64

04516 +.744230000000           OCT 174423000000,141000000000 +.33569335937500000000D-01  PH5   9
04517 +141000000000
04520 +173764400000            OCT 173764400000,140000000000 +.30548095703125000000D-01  PH5  10
04521 +140000000000
04522 +173707000000            OCT 173707000000,140000000000 +.27770996093750000000D-01  PH5  11
04523 +140000000000
04524 +173636300000            OCT 173636300000,140000000000 +.25291442871093750000D-01  PH5  12
04525 +140000000000
04526 +173572410000            OCT 173572410000,140000000000 +.23102760314941406250D-01  PH5  13
04527 +140000000000
04530 +173532762000            OCT 173532762000,140000000000 +.21177530288696289062D-01  PH5  14
04531 +140000000000
04532 +173477156000            OCT 173477156000,140000000000 +.19483327865600585937D-01  PH5  15
04533 +140000000000
04534 +173400000000      PH6   OCT 173400000000,140000000000 +.15625000000000000000D-01  PH6   6
04535 +140000000000
04536 +173600000000            OCT 173600000000,140000000000 +.23437500000000000000D-01  PH6   7
04537 +140000000000
04540 +173660000000            OCT 173660000000,140000000000 +.33671875000000000000D-01  PH6   8
04541 +140000000000
04542 +173670000000            OCT 173670000000,140000000000 +.26855468750000000000D-01  PH6   9
04543 +140000000000
04544 +173655000000            OCT 173655000000,140000000000 +.26184082031250000000D-01  PH6  10
04545 +140000000000
04546 +173631400000            OCT 173631400000,140000000000 +.24993896484375000000D-01  PH6  11
04547 +140000000000
04550 +173602600000            OCT 173602600000,140000000000 +.23603346679687500000D-01  PH6  12
04551 +140000000000
04552 +173553300000            OCT 173553300000,140000000000 +.22178649902343750000D-01  PH6  13
04553 +140000000000
04554 +173524524000            OCT 173524524000,140000000000 +.20792484283447265625D-01  PH6  14
04555 +140000000000
04556 +173477156000            OCT 173477156000,140000000000 +.19483327865600585937D-01   H6  15
04557 +140000000000
04560 +172400000000      PH7   OCT 172400000000,137000000000 +.78125000000000000000D-02  PH7   7
04561 +137000000000
04562 +172700000000            OCT 172700000000,137000000000 +.13671875000000000000D-01  PH7   8
04563 +137000000000
04564 +173430000000            OCT 173430000000,140000000000 +.17089843750000000000D-01  PH7   9
04565 +140000000000
04566 +173464000000            OCT 173464000000,140000000000 +.18798828125000000000D-01  PH7  10
04567 +140000000000
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      **FORTS7**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 65

04570 +1734764C0000           OCT 1734764C0000,14C0000000000 +.19439697265625000000D-01  PH7  11
04571 +1400000000000
04572 +1734764C0000           OCT 1734764C0000,14C0000000000 +.19439697265625000000D-01  PH7  12
04573 +1400000000000
04574 +1734764C0000           OCT 1734764C0000,14C0000000000 +.19439697265625000000D-01  PH7  13
04575 +1400000000000
04576 +1734764C0000           OCT 1734764C0000,14C0000000000 +.19439697265625000000D-01  PH7  14
04577 +1400000000000
04600 +1734764C0000           OCT 1734764C0000,14C0000000000 +.19439697265625000000D-01  PH7  15
04601 +1400000000000
04602 +1714000000000      PH8  OCT 1714000000000,1360000000000 +.3906250000000000000D-02  PH8   8
04603 +1360000000000
04604 +1724000000000           OCT 1724000000000,1370000000000 +.7812500000000000000D-02  PH8   9
04605 +1370000000000
04606 +1725400000000           OCT 1.254000000000,1370000000000 +.1074218750000000000D-01  PH8  10
04607 +1370000000000
04610 +1726400000000           OCT 1726400000000,1370000000000 +.1269531250000000000D-01  PH8  11
04611 +1370000000000
04612 +1727000000000           OCT 1727000000000,1370000000000 +.1388549804687500000D-01  PH8  12
04613 +1370000000000
04614 +1727340000000           OCT 1727340000000,1370000000000 +.1452636718750000000D-01  PH8  13
04615 +1370000000000
04616 +1727444000000           OCT 1727444000000,1370000000000 +.1478576660156250000D-01  PH8  14
04617 +1370000000000
04620 +1727444000000           OCT 1727444000000,1370000000000 +.1478576660156250000D-01  PH8  15
04621 +1370000000000
04622 +1704000000000      PH9  OCT 1704000000000,1350000000000 +.1953125000000000000D-02  PH9   9
04623 +1350000000000
04624 +1714400000000           OCT 1714400000000,1360000000000 +.4394531250000000000D-02  PH9  10
04625 +1360000000000
04626 +1716600000000           OCT 1716600000000,1360000000000 +.6591796875000000000D-02  PH9  11
04627 +1360000000000
04630 +1724210000000           OCT 1724210000000,1370000000000 +.8331298828125000000D-02  PH9  12
04631 +1370000000000
04632 +1724730000000           OCT 1724730000000,1370000000000 +.9613037109375000000D-02  PH9  13
04633 +1370000000000
04634 +1725302000000           OCT 1725302000000,1370000000000 +.1050567626953125000D-01  PH9  14
04635 +1370000000000
04636 +1725533000000           OCT 1725533000000,1370000000000 +.1108932495117187500D-01  PH9  15
04637 +1370000000000
04640 +1674000000000      PH10 OCT 1674000000000,1340000000000 +.9765625000000000000D-03  PH10 10
04641 +1340000000000
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      **FORTS7**        MODIFIED BY C. LAWSON AND C. DEVINE JUNE 1964          7/06/64     PAGE 66

04642 +1705000000000           OCT 1705000000000,1350000000000 +.2441406250000000000D-02  PH10 11
04643 +1350000000000
04644 +1714040000000           OCT 1714040000000,1360000000000 +.3967285156250000000D-02  PH10 12
04645 +1360000000000
04646 +1715360000000           OCT 1715360000000,1360000000000 +.5340576171875000000D-02  PH10 13
04647 +1360000000000
04650 +1716510000000           OCT 1716510000000,1360000000000 +.6484985351562500000D-02  PH10 14
04651 +1360000000000
04652 +1717444000000           OCT 1717444000000,1360000000000 +.7392883300781250000D-02  PH10 15
04653 +1360000000000
04654 +1664000000000      PH11 OCT 1664000000000,1330000000000 +.4882812500000000000D-03  PH11 11
04655 +1330000000000
04656 +1675400000000           OCT 1675400000000,1340000000000 +.1342773437500000000D-02  PH11 12
04657 +1340000000000
04660 +1704640000000           OCT 1704640000000,1350000000000 +.2349853515625000000D-02  PH11 13
04661 +1350000000000
04662 +1706700000000           OCT 1706700000000,1350000000000 +.3356933593750000000D-02  PH11 14
04663 +1350000000000
04664 +1714300400000           OCT 1714300400000,1360000000000 +.4280090332031250000D-02  PH11 15
04665 +1360000000000
04666 +1654000000000      PH12 OCT 1654000000000,1320000000000 +.2441406250000000000D-03  PH12 12
04667 +1320000000000
04670 +1666000000000           OCT 1666000000000,1330000000000 +.7324218750000000000D-03  PH12 13
04671 +1330000000000
04672 +1675500000000           OCT 1675500000000,1340000000000 +.1373291015625000000D-02  PH12 14
04673 +1340000000000
04674 +1704200000000           OCT 1704200000000,1350000000000 +.2075195312500000000D-02  PH12 15
04675 +1350000000000
04676 +1644000000000      PH13 OCT 1644000000000,1310000000000 +.1220703125000000000D-03  PH13 13
04677 +1310000000000
04700 +1656400000000           OCT 1656400000000,1320000000000 +.3967285156250000000D-03  PH13 14
04701 +1320000000000
04702 +1666400000000           OCT 1666400000000,1330000000000 +.7934570312500000000D-03  PH13 15
04703 +1330000000000
04704 +1634000000000      PH14 OCT 1634000000000,1300000000000 +.6103515625000000000D-04  PH14 14
04705 +1300000000000
04706 +1647000000000           OCT 1647000000000,1310000000000 +.2136230468750000000D-03  PH14 15
04707 +1310000000000
04710 +1624000000000      PH15 OCT 1624000000000,1270000000000 +.3051757812500000000D-04  PH15 15
04711 +1270000000000
                               END                                                                23390
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  LITERALS
04712  0000000000000
04713  0000000000001
04714  0000000000002
04715  0000000000003
04716  0000000000004
04717  0000000000005
04720  0000000000017
04721  0000000000022
04722  0000000000046
04723  2004000000000
04724  2014000000000
04725  2024000000000
04726  2026000000000
04727  2027400000000
04730  2034000000000
04731  2047400000000
04732  2054000000000
04733  2064000000000
04734  2064300000000
04735  2076440000000
04736  2104730000000
04737  2107220000000
04740  2330000000000
04741  3777777777777
04742  4000000000001
04743  6024000000000
04744  6036000000000
04745  6046000000000
04746  6047400000000
04747  6047600000000
04750  6053000000000
04751  6057400000000
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BINARY CARD NO. XPANCCOC
                  00000          ENTRY   XPAND                                   00280
    00000  0634 00  . 00065  XPAND SXA     XT,1                                  00290
    00001  0634 00 2 00066         SXA     XT+1,2                                00300
    00002  0634 00 4 00067         SXA     XT+2,4                                00310
    00003  0500 00 4 00001         CLA     1,4                                   00320
    00004  0621 00 0 00042         STA     ST2                                   00330
    00005  0767 00 0 00001         ALS     1                                     00340
    00006 -0737 00 2 00000         PLC     0,2                                   00350
    00007 -0634 00 2 00064         SXD     ST4,2                                 00360
    00010 -0634 00 2 00054         SXD     ST5,2                                 00370
    00011  0500 00 4 00002         CLA     2,4                                   00380
    00012  0621 00 0 00043         STA     STK                   B               00390
    00013  0621 00 0 00052         STA     STN2                                  00400
    00014  0621 00 0 00035         STA     STN                                   00410
    00015  0621 00 0 00057         STA     ST3                                   00420
    00016  0400 00 0 00102         ACC     =1                                    00430
    00017  0621 00 0 00036         STA     STN+1                                 00440
    00020  0500 00 0 00077         CLA     NM                    FI              00450
    00021  0621 00 0 00037         STA     LP                                    00460
    00022  0621 00 0 00041         STA     LP3                                   00470
    00023  0621 00 0 00043         STA     ST33                                  00480
    00024  0621 00 0 00056         STA     SK                                    00490
    00025  0500 00 0 00100         CLA     NM+1                  D1              00500
    00026  0621 00 0 00040         STA     LP2                                   00510
    00027  0621 00 0 00044         STA     ST44                                  00520
    00030  0774 00 1 00000         AXT     0,1                   (I)             00530
    00031  0600 00 0 00072         STZ     FI                                    00540
    00032  0600 00 0 00073         STZ     FI+1                                  00550
    00033  0774 00 2 00000         AXT     0,2                                   00560
    00034  0500 00 0 00103         CLA     =1.                                   00570
    00035  0601 00 0 00000    STN  STO     **                    B(0)            00580
    00036  0600 00 0 00000         STZ     **                    B+1(0)          00590
    00037  0443 00 2 00076  LP      DLC     A,2                                   00600
    00040  0361 00 2 00076  LP2     DFAD    A,2                                   00610
    00041 -0603 00 2 00076  LP3     DST     A,2                                   00620
    00042  0443 00 2 00076  ST2     DLC     A,2                                   00630
    00043  0303 00 2 00076  ST33    DFSB    A,2                                   00640
    00044  0361 00 2 00076  ST44    DFAD    A,2                                   00650
    00045 -0100 00 0 00056         TNZ     SK                                    00660
```

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```
    00046  1 77774 1 00047         TXI     **+1,1,-2                             00670
    00047  0754 00 0 00000         PXA                           ZERO OUT REMNDR 00680
    00050  0131 00 0 00000         ACA                                           00690
    00051  0754 00 0 00000         PXA                                           00700
    00052 -0603 00 1 00075  STN2    DST     A,1                                   00710
    00053  1 77776 1 00054         TXI     **+1,1,-2                             00720
    00054  3 00000 1 00052    STS  TXH     STN2,1,**                             00730
    00055  0020 00 0 00065         TRA     XT                                    00740
    00056 -0241 00 2 00076  SK      DFCP    A,2                                   00750
    00057  0261 00 1 00076  ST3     DFMP    A,1                                   00760
    00060  1 77776 1 00061         TXI     **+1,1,-2                             00770
    00061  0760 00 0 00062         CHS                                           00780
    00062  0765 00 0 00000         LRS     0                                     00790
    00063 -0603 00 1 00076  STK     DST     A,1                                   00800
    00064  3 00000 1 00037    ST4  TXH     LP,1,**                               00810
    00065  0774 00 1 00000    XT   AXT     **,1                                  00820
    00066  0774 00 2 00000         AXT     **,2                                  00830
    00067  0774 00 4 00000         AXT     **,4                                  00840
    00070  0020 00 4 00003         TRA     3,4                                   00850
    00071  0 00000 0 00000         PZE                           MAKE EVEN       00860
    00072                     FI    BSS     2                                     00870
    00074 +2014000000000          D1    DEC     1.,0                            00880
    00075 +0000000000C00
    00076  0 00000 0 00000  A       PZE                                           00890
    00077  0 00000 0 00072      NM  PZE     FI                                    00900
    00100  0 00000 0 00074          PZE     D1                                    00910
    00101  0 00000 0 00000         PZE                           MAKE EVEN
                                    END                                         00920

  LITERALS
  00102  0000000000001
  00103  2014000000000
```

```
                **DOUBLE PRECISION INNER PRODUCT ROUTINE   BEEMAN  CSC  20 APR62       7/01/64     PAGE 1


BINARY CARD NO. SCALR000
                    00000          ENTRY   SCALR                                                          00380
                                   *                                                                      00040
                                   *       CALLING SEQUENCE                                               00050
                                   *            CALL SCALR(A,B,N,ANS)                                     00060
                                   *                 WHERE A=DOUBLE PRECISION VECTOR A                    00070
                                   *                       B=DOUBLE PRECISION VECTOR B                    00080
                                   *                       N=NUMBER OF D.P. ELEMENTS IN A AND B           00090
                                   *                     ANS=D.P. INNERPRODUCT=(A,B)                      00100
                                   *                 NOTE....A AND B ARE STORED FORWARD                   00110
                                   *                        N IS STORED NEGATIVE                          00120
                                   *                                                                      00130
                                   *                                                                      00390
 00000  0634 00 1 00034  SCALR SXA     X1,1                                                              00400
 00001  0634 00 4 00035        SXA     X4,4                                                              00410
 00002  0500 60 4 00003        CLA*    3,4                                                               00430
 00003  0400 60 4 00003        ADD*    3,4                                                               00440
 00004  0402 00 0 00041        SUB     =1835                                                             00450
 00005  0621 00 0 00037        STA     TEMP                 2N-1                                         00460
 00006  0400 00 4 00001        ADD     1,4                                                               00470
 00007  0621 00 0 00026        STA     A                    SET ADDR(A+2N-1) IN A                        00480
 00010  0500 00 4 00002        CLA     2,4                                                               00490
 00011  0400 00 0 00037        ADD     TEMP                                                              00500
 00012  0621 00 0 00027        STA     B                    SET ADDR(B+N) IN B                           00510
 00013  0560 00 4 00004        CLA     4,4                                                               00520
 00014  0621 00 0 00023        STA     ZER                  SET ANSWER STORAGE LOCATIONS                 00530
 00015  0621 00 0 00030        STA     SUM                  **                                           00540
 00016  0621 00 0 00031        STA     ANS                  **                                           00550
 00017  0400 00 0 00041        ADD     =1835                                                             00560
 00020  0621 00 0 00024        STA     ZERL                                                              00570
 00021  0534 00 4 00037        LXA     TEMP,4                                                            00580
 00022 -0634 00 4 00033        SXD     CNT,4                SET TERMS COUNTER                            00590
 00023  0600 00 0 00000  ZER   STZ     **                   SET SUM TO ZERO                              00600
 00024  0600 00 0 00000  ZERL  STZ     **                                                                00610
 00025  0774 00 1 00001        AXT     1,1                                                               00620
 00026  0443 00 1 00026    A   DLC     A,1                  FORM INNERPRODUCT                            00630
 00027  0261 00 1 00027    B   DFMP    B,1                                                               00640
 00030  0301 00 0 00030  SUM   DFAD    SUM                                                               00650
 00031 -0603 00 0 00031  ANS   DST     ANS                                                               00660
 00032  1 00002 1 00033        TXI     CNT,1,2                                                           00670


                **DOUBLE PRECISION INNER PRODUCT ROUTINE   BEEMAN  CSC  20 APR62       7/01/64     PAGE 2

 00033 -3 00000 1 00026   CNT TXL     A,1,**                                                            00680
 00034  0774 00 1 00000    X1 AXT     **,1                                                              00690
 00035  0774 00 4 00000    X4 AXT     **,4                                                              00700
 00036  0020 00 4 00005       TRA     5,4                                                               00710
 00037  0 00000 0 00000  TEMP PZE                                                                       00720
 00040  0 00000 0 00000       PZE                  MAKES PROGRAM EVEN NUMBER OF STEPS
                               END                                                                      00730

  LITERALS
 00041  0000000C0001
```

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```
BINARY CARD NO. SMULT000
                    00000          ENTRY   SMULT                                    00260
00000  0634 00 1 00045  SMULT SXA     XIT,1                                        00290
00001  0634 00 2 00046         SXA     XIT+1,2                                      00300
00002  0634 00 4 00047         SXA     XIT+2,4                                      00310
00003  0500 00 4 00001         CLA     1,4                 A                        00320
00004  0621 00 0 00031         STA     A1                                           00330
00005  0771 00 0 00022         ARS     18                  B                        00340
00006  0621 00 0 00033         STA     B1                                           00350
00007  0500 00 4 00002         CLA     2,4                                          00360
00010  0621 00 0 00021         STA     C1                  C                        00370
00011  0621 00 0 00034         STA     C2                                           00380
00012  0621 00 0 00035         STA     C22                                          00390
00013  0767 00 0 00001         ALS     1                   2N IN DECR               00400
00014 -0737 00 2 00000         DC      ,2                  -2N                      00410
00015 -0634 00 2 00023         SXD     C1,2                                         00420
00016 -0634 00 2 00042         SXD     D3,2                                         00430
00017 -0634 00 2 00044         SXD     D4,2                                         00440
                         * ZERO  OUT C  ARRAY                                      00450
00020  0774 00 4 00000         AXT     0,4                                          00460
00021  0600 00 4 00000      C1 STZ     C,4                 C                        00470
00022  1 77777 4 00023         TXI     *+1,4,-1                                     00480
00023  3 00000 4 00021      C1 TXH     *-2,4,**                                     00490
                         *                                                         00500
00024  0774 00 1 00000         AXT     0,1                 I                        00510
00025  0634 00 0 00032   LOOP1 SXA     PX4,0               J                        00520
00026  0754 00 1 00000         PAX     ,1                                           00530
00027  0734 00 2 00000         PAX     ,2                  K=I                      00540
00030  0634 00 1 00041         SXA     SAVX1,1                                      00550
00031  0443 00 1 00051  A1     DLD     A,1                                          00560
00032  0774 00 1 00000     PX4 AXT     **,1                                         00570
00033  0261 00 1 00051  B1     DFMP    A,1                                          00580
00034  0321 00 2 00051  C2     DFAD    A,2                                          00590
00035 -0603 00 2 00051  C22    DST     A,2                                          00600
00036  1 77776 2 00037    SKP1 TXI     **+1,2,-2                                    00610
00037  1 77776 1 00040         TXI     **+1,1,-2                                    00620
00040  0634 00 1 00032         SXA     PX4,1                                        00630
00041  0774 00 1 00000   SAVX1 AXT     **,1                                         00640
00042  3 00000 2 00031      D3 TXH     A1,2,**             ***-2N                   00650
00043  1 77776 1 00044         TXI     **+1,1,-2                                    00660
```

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```
00044  3 00000 1 00025      D4 TXH     LOOP1,1,**                                   00670
00045  0774 00 1 00000    XIT AXT     **,1                                         00680
00046  0774 00 2 00000         AXT     **,2                                         00690
00047  0774 00 4 00000         AXT     **,4                                         00700
00050  0020 00 4 00003         TRA     3,4                                          00710
00051  0 00000 0 00000  A      PZE                                                  00720
                               END                                                  00730
```

```
**INTRP **  MODIFIED BY C.J.DEVINE,C.L.LAWSON, JPL, JUNE 25,1964          7/01/64     PAGE 1

*                    ORIGINALLY WRITTEN BY R.J.KREPPER,          1962
*          S U B R O U T I N E   I N T R P                                          00020
*****************************************************************************    00040
*                                                                           *      00050
*     CALLING SEQUENCE (FORTRAN COMPATIBLE)                                 *      00060
*                                                                           *      00070
*          TSX    INTRP,4                                                   *      00080
*                                                                           *      00090
*          TSX    ADDRESS FOR TYPE OF DIFFERENCE LINE AT 0 (FLOATING        *      00100
*                 POINT DOUBLE PRECISION)                                   *      00110
*                                                                           *      00120
*          TSX    ADDRESS FOR DESIRED INTERPOLATION TYPE (FLOATING          *      00130
*                 POINT DOUBLE PRECISION)                                   *      00140
*                                                                           *      00150
*          TSX    FIRST ADDRESS OF THE DIFFERENCE ARRAY  (FLOATING          *      00160
*                 POINT DOUBLE PRECISION)                                   *      00170
*                                                                           *      00180
*          TSX    ADDRESS OF STEP SIZE (FLOATING POINT DOUBLE               *      00190
*                 PRECISION)                                                *      00200
*                                                                           *      00210
*          TSX    ADDRESS FOR THE DESIGNATE FOR THE DERIVATIVE TO BE        *      00220
*                 INTERPOLATED (FIXED POINT 835 )                           *      00230
*                                                                           *      00240
*          TSX    ADDRESS OF THE ORDER OF THE DIFFERENCE AVAILABLE          *      00250
*                 (FIXED POINT 835)                                         *      00260
*                                                                           *      00270
*          TSX    ADDRESS OF ANSWER (FLOATING POINT DOUBLE PRECISION)       *      00280
*                                                                           *      00290
*          TSX    ERROR RETURN                                              *      00300
*                                                                           *      00310
*          TSX    NORMAL RETURN                                             *      00320
*                                                                           *      00330
*****************************************************************************    00340

BINARY CARD NO. INTRP00C
     00274          ENTRY   .INTRP                                                00360

     TRANSFER VECTOR

BINARY CARD NO. INTRP001
    00000  676721432460     XPAND
    00001  674464436360     SPLIT

**INTRP **  MODIFIED BY C.J.DEVINE,C.L.LAWSON, JPL, JUNE 25,1964          7/01/64     PAGE 2

    00002  622321435160     SCALR

    00003 +2014000C0000      LOG    OCT     2014000C0C0C,1460000C00C0C                LOG   1   02280
    00004 +1460000CCC00
    00005 +2004000C0000              OCT     2004000C0C0C,1450C0C0000C                 LOG   2   02290
    00006 +1450000C0000
    00007 +177525252525              OCT     177525252525,144252525253                 LOG   3   02300
    00010 +144252525253
    00011 +1774000C0000              OCT     1774000C0C0C,144900000000                 LOG   4   02310
    00012 +1440000C0000
    00013 +176631463146              OCT     176631463146,143214631463                 LOG   5   02320
    00014 +143314631463
    00015 +176525252525              OCT     176525252525,143252525253                 LOG   6   02330
    00016 +143252525253
    00017 +176444444444              OCT     176444444444,143444444445                 LOG   7   02340
    00020 +143444444445
    00021 +1764000C0000              OCT     1764000C0C0C,1430C0000C0C                 LOG   8   02350
    00022 +1430000C0000
    00023 +175707070707              OCT     175707070707,142079707071                 LOG   9   02360

BINARY CARD NO. INTRP002
    00024 +14207070C7071
    00025 +175631463146              OCT     175631463146,142314631463                 LOG  10   02370
    00026 +142314631463
    00027 +175564272135              OCT     175564272135,142056427214                 LOG  11   02380
    00030 +142056427214
    00031 +175525252525              OCT     175525252525,142252525253                 LOG  12   02390
    00032 +142252525253
    00033 +175473047304              OCT     175473047304,142730473047                 LOG  13   02400
    00034 +142730473047
    00035 +175444444444              OCT     175444444444,142444444445                 LOG  14   02410
    00036 +142444444445
    00037 +175421042104              OCT     175421042104,142210421042                 LOG  15   02420
    00040 +142210421042
    00041 +175400000000              OCT     1754000C0000,142000000000                 LOG  16   02430
    00042 +142000000000
    00043 +174741703607              OCT     174741703607,141417036074                 LOG  17   02440
    00044 +141417036074
    00045 +174707070707              OCT     174707070707,141070707071                 LOG  18   02450
    00046 +141070707071
    00047 +2014000C0000      LOG1    OCT     2014000C0C0C,1460000000000                LOG1  1   02460
```

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**INTRP **  MODIFIED BY C.J.DEVINE,C.L.LAWSON, JPL, JUNE 25,1964          7/01/64     PAGE 3

BINARY CARD NO. INTRP003
    00050 +1460300C0000
    00051 -2004000C0C00                 OCT     4004000C0000,5450000000C0                       LOG1  2   02470
    00052 -1450000C0C00
    00053 -175525252525                 OCT     575525252525,542252525250                       LOG1  3   02480
    00054 -142252525250
    00055 -174525252525                 OCT     574525252525,541252525260                       LOG1  4   02490
    00056 -141252525260
    00057 -173660266026                 OCT     573660266026,540602660260                       LOG1  5   02500
    00060 -140602660260
    00061 -173463146314                 OCT     573463146314,540631453044                       LOG1  6   02510
    00062 -140631463144
    00063 -172723445071                 OCT     572723445071,527726723450                       LOG1  7   02520
    00064 -137761723450
    00065 -172564371164                 OCT     572564371164,537371164432                       LOG1  8   02530
    00066 -137371164432
    00067 -172462460505                 OCT     572462460505,537274452035                       LOG1  9   02540
    00070 -137274452035
    00071 -172402677052                 OCT     572402677052,537565544601                       LOG1 10   02550
    00072 -137565544601
    00073 -171674597257                 OCT     571674597257,536023460716                       LOG1 11   02560

BINARY CARD NO. INTRP004
    00074 -136023460716
    00075 -171604172262                 OCT     571604172262,536147565550                       LOG1 12   02570
    00076 -136147565550
    00077 -171527142211                 OCT     571527142211,536101546374                       LOG1 13   02580
    00100 -136101546374
    00101 -171462426432                 OCT     571462426432,536573445500                       LOG1 14   02590
    00102 -136573445500
    00103 -171424166250                 OCT     571424166250,536052351364                       LOG1 15   02600
    00104 -136052351364
    00105 -170765462703                 OCT     570765462703,535321312574                       LOG1 16   02610
    00106 -135321312574
    00107 -170712317131                 OCT     570712317131,535525634176                       LOG1 17   02620
    00110 -135525634176
    00111 -170645251150                 OCT     570645251150,535272751124                       LOG1 18   02630
    00112 -135272751124
    00113 +2014003C0000      P0         OCT     2014000C0C0C,1460000C0C0C                       P0    1   19310
    00114 +1460000C0000
                00113     LOG2 EQU     PC
    00115 -2014000C0000                 OCT     6014000C0C0C,5460000C0000                       P0    2   19320

**INTRP **  MODIFIED BY C.J.DEVINE,C.L.LAWSON, JPL, JUNE 25,1964          7/01/64     PAGE 4

    00116 -1460000C0000
    00117 +175525252525                 OCT     175525252525,142252525253                       P0    3   19330

BINARY CARD NO. INTRP005
    00120 +142252525253
    00121 +CC0000C0C0C0                 OCT     CC0C000C0C0C,000000C000C0                       P0    4   19340
    00122 +0000000C0000
    00123 -171421042104                 OCT     571421042104,536210421042                       P0    5   19350
    00124 -136210421042
    00125 -171421042104                 OCT     571421042104,536210421042                       P0    6   19360
    00126 -136210421042
    00127 -170736746422                 OCT     570736746422,535114736747                       P0    7   19370
    00130 -135114736747
    00131 -170633610633                 OCT     570633610633,535610633611                       P0    8   19380
    00132 -135610633611
    00133 -170543013525                 OCT     570543013525,535275121752                       P0    9   19390
    00134 -135275121752
    00135 -170464557076                 OCT     570464557076,535752C01411                       P0   10   19400
    00136 -135752C01411
    00137 -170417016410                 OCT     570417016410,535525447047                       P0   11   19410
    00140 -135525447047
    00141 -167740212305                 OCT     567740212305,534214176415                       P0   12   19420
    00142 -134214176415
    00143 -167655072106                 OCT     567655072106,534352306044                       P0   13   19430

BINARY CARD NO. INTRP006
    00144 -134352306044
    00145 -167602235216                 OCT     567602235216,534037217302                       P0   14   19440
    00146 -134037217302
    00147 -167536075337                 OCT     567536075337,534213641034                       P0   15   19450
    00150 -134213641034
    00151 -167477170304                 OCT     567477170304,534670501037                       P0   16   19460
    00152 -134670501037
    00153 -167444511335                 OCT     567444511335,534330733076                       P0   17   19470
    00154 -134330733076
    00155 -167415440566                 OCT     567415440566,534257452131                       P0   18   19480
    00156 -134257452131
    00157                      TEMP     BSS     2                                                        02240
    00161                      MQ       BSS     2                                                        02250
    00163                      BSERI    BSS     36                                                       02260
    00227                      PSERI    BSS     36                                                       02270
    00273                      NCOFF    BSS     1                                                        02230
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**INTRP **  MODIFIED BY C.J.DEVINE,C.L.LAWSON, JPL, JUNE 25,1964          7/01/64     PAGE 5

                                    *
                                    *
BINARY CARD NO. INTRPC07
    00274  C634 00 4 00473   INTRP SXA     XR4,4                                          00620
    00275  C634 00 2 00473         SXA     XR2,2                                          00630
    00276  C634 00 1 00474         SXA     XR1,1                                          00640
    00277  0534 00 1 00472         LXA     XR4,1                                          00650
                                    ********************************************************00660
                                    *                                                      *00670
                                    *     A TEST IS PERFORMED TO DETERMINE WHETHER (T - M + N) IS LESS    *00680
                                    *     THAN OR EQUAL TO (T + M) AND (T) IS GREATER THAN OR EQUAL TO    *00690
                                    *     (T + M).                                         *00700
                                    *                                                      *00710
                                    ********************************************************00720
    003C0  0500 60 1 00CC6           CLA*    6,1                                            00730
    00301 -C501 60 0 205C2           ORA     *C233C0C0C0C00                                 00740
    00302  C300 00 0 005C2           FAD     =C*33000000000                                 00750
    00303  0131 00 0 00CC0           XCA                                                    00760
    00304  C260 60 1 00CC4           FMP*    4,1                                            00770
    00305  C601 00 0 00157           STO     TEMP                                           00780
    00306  0500 60 1 00CC1           CLA*    1,1                                            00790
    00307  0302 00 0 00157           FSB     TEMP                                           00800
    00310  C340 60 1 00CC2           CAS*    2,1                                            00810
    00311  0020 60 1 00C1C           TRA*    8,1                                            00820
    00312  0020 00 0 00314           TRA     OK                                             00830
    00313  0020 00 0 00314           TRA     OK                                             00840
    00314  0500 60 1 00CC2   OK      CLA*    2,1                                            00850
    00315  C340 60 1 00CC1           CAS*    1,1                                            00860
    00316  CC20 60 1 00C1C           TRA*    8,1                                            00870
    00317  0020 00 0 00320           TRA     **1                                            00880
                                    ********************************************************00890
                                    *                                                      *00900
                                    *     COMPUTE  MU                                      *00910
                                    *                        MU = (TC - T) / N             *00920
                                    *                                                      *00930
                                    ********************************************************00940
BINARY CARD NO. INTRPC08
    00320  0500 60 1 00C01           CLA     1,1                                            00950
    00321  C621 00 0 00326           STA     TIME                                           00960
    00322  0500 00 1 00CC2           CLA     2,1                                            00970
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**INTRP **  MODIFIED BY C.J.DEVINE,C.L.LAWSON, JPL, JUNE 25,1964          7/01/64     PAGE 6

    00323  C621 00 0 00327           STA     TC                                             00980
    00324  0500 00 1 00004           CLA     4,1                                            00990
    00325  C621 00 0 00330           STA     STEP                                           01000
    00326  0443 00   00CCC   TIME    DLC     **                                             01010
    00327  C303 00 0 00CCC     TC    DFSB    **                                             01020
    00330 -C241 00 0 00CC0   STEP    DFCP    **                                             01030
    00331 -0603 00 0 00161           DST     MU                                             01040
    00332  0500 60 1 00CC6           CLA*    6,1                                            01050
    00333  0400 00 0 00477           ADD     =3                                             01060
    00334  0402 60 1 00CC5           SUB*    5,1                                            01070
    00335  0601 00 0 00273           STO     NCOEF                                          01080
    00336  0767 00 0 00C22           ALS     18                                             01090
    00337  0622 00 0 00341           STO     **2                                            01100
    00340  0074 00 4 00000           TSX     &XPAND,4                                       01110
    00341  0 00000 0 00161           PZE     MU,,**                                         01120
    00342  0 00000 0 00163           PZE     &SERR                                          01130
    00343  0500 60 1 00CC5           CLA*    5,1                                            01140
BINARY CARD NO. INTRPC09
    00344  0737 00 2 00000           PAC     ,2                                             01150
    00345  C020 00 2 00346           TRA     *+1,2                                          01160
    00346  0020 00 0 00352           TRA     NO                                             01170
    00347  0020 00 0 00402           TRA     N1                                             01180
    00350  0020 00 0 00460           TRA     N2                                             01190
    00351  0020 00 0 00431           TRA     N3                                             01200
                                    ********************************************************01210
                                    *                                                      *01220
                                    *     WHEN N = 0,  COMPUTE  X(N - MU)                  *
                                    *                                                      *01240
                                    *              X(N - MU)  = ((N**2*(1 - DELTA)**MU) / LN**2*(1 -  *01250
                                    *                                                      *01260
                                    *          DELTA)) * XOC(N)                            *01270
                                    *                                                      *01280
                                    ********************************************************01290
    00352  0500 00 0 00273   NO      CLA     NCOEF                                          01300
    00353  0767 00 0 00C22           ALS     18                                             01310
    00354  0622 00 0 00357           STO     **3                                            01320
    00355  0074 00 4 00001           TSX     &SPLIT,4                                       01330
    00356  0 00163 0 00113           PZE     LOG2,,&SERR                                    01340
    00357  0 00000 0 00227           PZE     &SERR,,**                                      01350
    00360  0500 00 1 00CC3           CLA     3,1                                            01360
    00361  0621 00 0 00364           STA     **3                                            01370
```

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     **INTRP **  MODIFIED BY C.J.DEVINE,C.L.LAWSON, JPL, JUNE 25,1964          7/01/64     PAGE 7

 00362  0074 60 4 00002          CALL    SCALR,MSERI,**,NCOEF,TEMP                              01380
 00363  0074 00 0 00227
 00364  0074 00 0 00000
 00365  0074 00 0 00273
 00366  0074 00 0 00157
 00367  0534 00 1 00472          LXA     XR4,1                                                  01390

BINARY CARD NO. INTRP01C
 00370  0500 00 1 00007          CLA     7,1                                                    01400
 00371  0621 00 0 00460          STA     DOWN7                                                  01410
 00372  0500 00 0 00330          CLA     STEP                                                   01420
 00373  0621 00 0 00375          STA     N4                                                     01430
 00374  0621 00 0 00376          STA     N8                                                     01440
 00375  0443 00 0 00000      N4  DLC     **                                                     01450
 00376  0261 00 0 00000      N8  DFMP    **                                                     01460
 00377  0261 00 0 00157          DFMP    TEMP                                                   01470
 00400 -0603 00 0 00000  DOWN7 DST     **                                                     01480
 00401  0020 00 0 00472          TRA     XR4                                                    01490
                                *****************************************************************01500
                                *                                                               * 01510
                                *      WHEN N = 1,  COMPUTE  XDIN - PU)                         *
                                *                                                               * 01530
                                *                XDIN - PU) = ((H*(1 - DELTA)**MU) /-LA*(1 - DELTA))  *
                                *                                                               * 01550
                                *             * XDD(N)                                          * 01560
                                *                                                               * 01570
                                *****************************************************************01580
 00402  0500 00 0 00273      N1  CLA     NCOEF                                                  01590
 00403  0767 00 0 00022          ALS     18                                                     01600
 00404  0622 00 0 004C7          STD     **3                                                    01610
 00405  0074 00 4 00001          TSX     $SMULT,4                                               01620
 00406  0 00163 0 00047          PZE     LCG1,,BSERI                                            01630
 00407  0 00000 0 00227          PZE     MSERI,,**                                              01640
 00410  0500 00 1 00003          CLA     3,1                                                    01650
 00411  0400 00 0 00476          ADD     =3                                                     01660
 00412  0621 00 0 00415          STA     ZAAT+2                                                 01670
 00413  0074 00 4 00002  ZAAT   CALL    SCALR,MSERI,**,NCOEF,TEMP                              01680

BINARY CARD NO. INTRP01I
 00414  0074 00 0 00227
 00415  0074 00 0 00000
 00416  0074 00 0 00273
```

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     **INTRP **  MODIFIED BY C.J.DEVINE,C.L.LAWSON, JPL, JUNE 25,1964          7/01/64     PAGE 8

 00417  0074 00 0 00157
 00420  0534 00 1 00472          LXA     XR4,1                                                  01690
 00421  0500 00 1 00007          CLA     7,1                                                    01700
 00422  0621 00 0 00427          STA     DOWN5                                                  01710
 00423  0500 00 0 00330          CLA     STEP                                                   01720
 00424  0621 00 0 00425          STA     **1                                                    01730
 00425  0443 00 0 00000          DLC     **                                                     01740
 00426  0261 00 0 00157          DFMP    TEMP                                                   01750
 00427 -0603 00 0 00000  DOWN5 DST     **                                                     01760
 00430  0020 00 0 00472          TRA     XR4                                                    01770
                                *****************************************************************01780
                                *                                                               * 01790
                                *      WHEN N = 3,  COMPUTE  XDDDIN - PU)                       *
                                *                                                               * 01810
                                *                XDDDIN - PU)    = (-LA(1-DELTA)*(1-DELTA)**PU/H  *
                                *                                                               * 01830
                                *             * XDD(N)                                          * 01840
                                *                                                               * 01850
                                *****************************************************************01860
 00431  0500 00 0 00273      N3  CLA     NCOEF                                                  01870
 00432  0767 00 0 00022          ALS     18                                                     01880
 00433  0622 00 0 00436          STD     **3                                                    01890
 00434  0074 00 4 00001          TSX     $SMULT,4                                               01900
 00435  0 00163 0 00003          PZE     LCG,,BSERI                                             01910
 00436  0 00000 0 00227          PZE     MSERI,,**                                              01920
 00437  0500 00 4 00003          CLA     3,4                                                    01930

BINARY CARD NO. INTRP012
 00440  0400 00 0 00501          ADD     =6                                                     01940
 00441  0621 00 0 00444          STA     N4+2                                                   01950
 00442  0074 00 4 00002      N4  CALL    SCALR,MSERI,**,NCOEF,TEMP                              01960
 00443  0074 00 0 00227
 00444  0074 00 0 00000
 00445  0074 00 0 00273
 00446  0074 00 0 00157
 00447  0534 00 1 00472          LXA     XR4,1                                                  01970
 00450  0500 00 1 00007          CLA     7,1                                                    01980
 00451  0621 00 0 00456          STA     N6                                                     01990
 00452  0500 00 0 00330          CLA     STEP                                                   02000
 00453  0621 00 0 00455          STA     N5                                                     02010
 00454  0443 00 0 00157          DLC     TEMP                                                   02020
 00455 -0241 00 0 00000      N5  DFDP    **                                                     02030
```

```
     **INTPP **  MODIFIED BY C.J.DEVINE,C.L.LAWSON, JPL, JUNE 25,1964          7/01/64     PAGE 9

00456 -0603 00 0 00000      N6 OST     **                                                  02040
00457  7020 00 0 00472         TRA     XR4                                                 02050
                           ***********************************************************    02060
                           *                                                         *     02070
                           *     WHEN N = 2,  COMPLTE  XDD(N - PU)                   *
                           *                                                         *     02090
                           *                XDD(N - PU) = ((1 - DELTA)**PU) * XDD(N)   *
                           *                                                         *     02110
                           ***********************************************************    02120
00460  0500 00 1 00003   N2   CLA     3,1                                                 02130
00461  0400 00 0 00300         ADD     =4                                                  02140
00462  0321 00 0 00466         STA     SQ+1                                                02150
00463  0500 00 1 00007         CLA     7,1                                                 02160

BINARY CARD NO. INTRP013
00464  0621 00 0 00471         STA     SQ+4                                                02170
00465  0074 00 4 00002   SQ    CALL    SCALR,**,BSERI,NCOEF,**                             02180
00466  0074 00 0 00000
00467  0074 00 0 00163
00470  0074 00 0 00273
00471  0074 00 0 00000
00472  0774 00 4 00000   XR4   AXT     **,4                                                02190
00473  0774 00 2 00000   XR2   AXT     **,2                                                02200
00474  0774 00 1 00000   XR1   AXT     **,1                                                02210
00475  0020 00 4 00311         TRA     9,4                                                 02220
                               END

  LITERALS
00476  000000000002
00477  000000000003
00500  000000000004
00501  000000000006
00502  233000000000
```

```
TSTOP  RESIDUAL COMPUTATION  CHARLES J. DEVINE                          7/01/64        PAGE 1

      SUBROUTINE TSTOP (      NTAPE,LTAPE,KTAPE,           DELTA, TIME,
     1               DELT,COSOB,SINOB,CMAT,XLB,  XJDO    ,XYZ ,VXYZ,
     1                    KAM,LAM,KAN,NWRITE,NPRINT                    )
D     DIMENSION XLBB(3)   ,XJC(1) ,XLB(3)
D     DIMENSION COSOB(1),SINOB(1),DELT(3),XYZ(3),VXYZ(3),CMAT(3,3),XJDO(
     11)
D     DIMENSION DELTA(3)
D     DIMENSION   VCLO(3)
D     DIMENSION CDATE(1),XCLC(3)
      DIMENSION DUM(14966),DUM2(6),V3L(1),V3M(1),V2L(1),V2M(1),
     1V1L(1),V1M(1),VZL(1),VZM(1),VYL(1),VYM(1),V1L(1),VXM(1),
     2XJL(1),XJM(1)
      COMMON DUM1 ,     DUM2  , V3L,V3M,VZL,V2M,V1L,V1M,VZL,VZM,
     1VYL,VYM,VXL,VXM,XJL,XJM
C     FLIP STORAGE FROM FAP TO FORTRAN
      XJC(1)=XJM
      XJC(2)=XJL
      XYZ(1)=VXM
      XYZ(4)=VXL
      XYZ(2)=VYM
      XYZ(5)=VYL
      XYZ(3)=VZM
      XYZ(6)=VZL
      VXYZ(1)=V1M
      VXYZ(4)=V1L
      VXYZ(2)=V2M
      VXYZ(5)=V2L
      VXYZ(3)=V3M
      VXYZ(6)=V3L
D     TIME=XJC-XJDO
  5   READ TAPE NTAPE,CDATE(1),CDATE(2),(XCLO(ME),XOLO(ME+3) ME=1,3),
     1                                 (VCLO(ME),VCLC(ME+3),ME=1,3)
D     IF(CDATE-XJC)5,4,4
  4   CONTINUE
 3C0  CONTINUE
      DC 13 I=1,3
D     DELT(I)=XCLC(I)-XYZ(I)
D 13  DELTA(I)=DELT(I)
      GC TO (21,26),LAM
   12 FORMAT( F10.1, 6F11.8, 7P3F14.4  )
   21 WRITEOUTPUTTAPE 6,12, XJM,       (XYZ(I),I=1,3),
```

```
TSTOP  RESIDUAL COMPUTATION  CHARLES J. DEVINE                          7/01/64        PAGE 2

     1                                 (VXYZ(I),I=1,3),
     2                                 (CELT (I),I=1,3)
  26 CONTINUE
     NRCT=1
     CALL STINKS(XYZ ,VXYZ,CELT,XLB ,CMAT,COSOB,SINOB,NRCT)
     GC TO (49,51),LAM
  49 WRITE OUTPUT TAPE 6,50,  ( XYZ(I),I=1,3),(VXYZ(I),I=1,3),
    1              CELT (3),(DELT (I),I=1,2)
   50 FORMAT(1CX,6F11.8,7P3F14.4
  51 CONTINUE
     GC TO (1C0,2001),KAM
 1C0   CONTINUE
     NRCT=2
     CALL STINKS(XCLO,VOLC,CELT,XLBB,CMAT,COSOB,SINOB,NRCT)
     DC 15 I=1,3
D 15 XLBB(I)=XLBB(I)-XLB(I)
     WRITE OUTPUT TAPE 6,16,(XLBB(I),I=1,3)
  16 FORMAT(76X,7P3F14.4)
 200 CONTINUE
C    EPHEMERIS WRITE HERE
     GC TO (60,66),NWRITE
  60 CONTINUE
     GC TO (61,62,63,64),NPRINT
  61 WRITE TAPE LTAPE,XJM,XJL,VXM,VXL,VYM,VYL,VZM,VZL,V1M,V1L,V2M,V2L,V
     13M,V3L
     WRITE TAPE KTAPE,XJD(1),XJD(2),(DELTA(I),I=1,3),  DELT(3),
     1                 (CELT (I),I=1,2)
     GC TO 64
  62 WRITE TAPE LTAPE,XJM,XJL,VXM,VXL,VYM,VYL,VZM,VZL,V1M,V1L,V2M,V2L,V
     13M,V3L
     GC TO 64
  63 WRITE TAPE KTAPE,XJD(1),XJD(2),(DELTA(I),I=1,3),  DELT(3),
     1                 (CELT (I),I=1,2)
  64 CONTINUE
     GC TO (65,66),KAN
  65 CONTINUE
     WRITEOUTPUTTAPE6,12,XJM,VXM,VYM,VZM,V1M,V2M,V3M
     2                                 (DELTA(I),I=1,3)
     WRITE OUTPUT TAPE 6,50,  (XYZ (I),I=1,3),(VXYZ(I),I=1,3),
     1            CELT (3),(DELT (I),I=1,2)
  66 CONTINUE
     RETURN
```

```
TSTOP  RESIDUAL COMPUTATION  CHARLES J. DEVINE                          7/01/64        PAGE 3

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

```
 STINKS     ROTATION SUBROUTINE  CHARLES J. DEVINE                          7/01/64        PAGE 1

      SUBROUTINE STINKS(XYZ,X1DOT,DELTA,XLB,CMAT,       COSOB,SINOB,NROT
     1)
C
C
C     SUBROUTINE STINK DOES THE FOLLOWING
C     (1) ROTATES XYZ AND VELOCITY TO ECLIPTIC
C     (2) ROTATES DELTA(XYZ) TO ECLIPTIC
C     (3) COMPUTES RHO, LONGITUDE, LATITUDE IN ECLIPTIC, BY CALLING SPHE
C     (4) COMPUTES CMATRIX ,AND NEW DELTA WHICH IS B MATRIX, THAT
C     (5) IS, COS(BETA)*DELTAL, DELTA(BETA), AND DELTA(RHO)
D     DIMENSION  XYZ(3),X1DOT(3),DELTA(3),XLB(3),CMAT(3,3),COSOB(1),
     1          SINOB(1),X(3),D(3),RHO(1),XL(1),XB(1),DEL(3)
C     ROTATE POSITION AND VELOCITY AND DELTA
      NS=1
    5 DO 10 I=1,3
      GO TO (7,8,9),NS
D   7 X(I)=XYZ(I)
      GO TO 10
D   8 X(I)=X1DOT(I)
      GO TO 10
D   9 X(I)=DELTA(I)
   10 CONTINUE
D     D(1)=X(1)
D     D(2)= X(2)*COSOB+X(3)*SINOB
D     D(3)=-X(2)*SINOB+X(3)*COSOB
      GO TO (15,20,25),NS
   15 DO 16 I=1,3
D  16 XYZ(I)=D(I)
D     U=D(1)
D     V=D(2)
D     W=D(3)
      CALL SPHER(U,V,W,RHO,XL,XB)
C     XLB(1)=RHO
D     XLB(2)=XL
D     XLB(3)=XB
      NS=2
      GO TO 5
   20 DO 17 I=1,3
D  17 X1DOT(I)=D(I)
      NS=3
      GO TO 5
```

```
 STINKS     ROTATION SUBROUTINE  CHARLES J. DEVINE                          7/01/64        PAGE 2

C
   25 DO 18 I=1,3
D  18 DEL (I)=D(I)/RHO
      GO TO (40,45),NROT
   40 CONTINUE
C     NOW COMPUTE CMATRIX
      CONTINUE
D     SINXL=SINF(XL)
D     SINXB=SINF(XB)
D     COSXL=COSF(XL)
D     COSXB=COSF(XB)
C
C     CMAT(1,1)=-SINXL
C     CMAT(1,2)=COSXL
D     CMAT(1,3)=0.0
D     CMAT(2,1)=-SINXB*COSXL
D     CMAT(2,2)=-SINXB*SINXL
D     CMAT(2,3)=COSXB
D     DO 30 I=1,3
D  30 CMAT(3,I)=XYZ(I)/RHO
      DO 32 I=1,3
D  32 DELTA(I)=0.0
      DO 35 I=1,3
      DO 35 J=1,3
D  35 DELTA(I)=DELTA(I)+CMAT(I,J)*DEL(J)
      DO 59 I=1,3
      DO 59 J=1,3
D 59  CMAT(I,J)=CMAT(I,J)/RHO
   45 CONTINUE
      RETURN
      END(1,0,C,0,0,0,C,1,0,C,1,0,0,C,C,0)
```

```
 SET32  NORMAL EQUATIONS            CHARLES J. DEVINE

      SUBROUTINE SET32(PQR,XYZ,X1DOT,A,E,XN,SET, TIME,CMAT)
C     SET32 IS A MODIFICATION OF RED3
D     DIMENSION A(1),E(1),XN(1),TIME(1)
D     DIMENSION SET3(3,6),VELN(3),PQR(3,3),POS(3),X1DOT(3),SET(6,6),
     1          XYZ(3),CMAT(3,3)
      DO 178 JO=1,3
D178  POS(JO)=XYZ(JO)
D     RRDOT=POS(1)*X1DOT(1)+POS(2)*X1DOT(2)+POS(3)*X1DOT(3)
D     G=E
D     F=A
D     ESQR=G**2
D     B=F*(1.0-ESQR)
D     R=SQRTF(POS(1)**2+POS(2)**2+POS(3)**2)
D     AB=G*B
D     XKO=(R-F*(1.0+ESQR))/AB
D     AA=F**2
D     XNN=XN**2
D     DIV=AA*XNN*G
D     DIVR=RRDOT/DIV
D     RB=R/B
D     RBI=1.0+RB
D     XKO=DIVR*RBI
      DO 20 I=1,3
D  20 VELN(I)=X1DOT(I)/XN
      IX=1
      IY=2
      IZ=3
   21 I=IX
      J=I+3
C     OF PAGES 237,241 IN BROUWER AND PRIVATE COMMUNICATION
D     SET3(I,1)=+VELN(IX)
D     SET3(I,2)=+PQR(1,IY)*  POS( Z)-PQR(1,IZ)*  POS(IY)
D     SET3(I,3)=+PQR(2,IY)*  POS(IZ)-PQR(2,IZ)*  POS(IY)
D     SET3(I,5)=    +  POS(IX)-1.5*TIME*X1DOT(IX)
D     SET3(I,4)=(-VELN(IX)+PQR(3,IY)*  POS(IZ)-PQR(3,IZ)*  POS(IY))/G
D     SET3(I,6)=XKO*POS(IX)+XKO*X1DOT(IX)
      IF (IX- )22,23,22
   22 ITEMP=I
      IX=IY
      IY=IZ
      IZ=ITEMP
```

```
 SET32  NORMAL EQUATIONS            CHARLES J. DEVINE

      GO TO 21
   23 CONTINUE
      DO 50 I=1,3
      DO 50 J=1,6
D 50  SET(I,J)=0.0
C     COMPUTE C * SET III MATRIX
      DO 40 J=1,3
      DO 40 L=1,6
      DO 40 K=1,3
D  40 SET(J,L)=SET(J,L)+CMAT(J,K)*SET3(K,L)
      RETURN
      END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

```
 SETUP2      SETS UP NORMAL MATRIX    CHARLES J. DEVINE                    7/01/67        PAGE 1

      SUBROUTINE SETUP2(SET,DELTA,XNUM,SIGSQ,AMAT,BMAT,MMAX,NMAX,
     1                  NGOSOL,STEST,WT)
C
C     THIS SUBR WILL FORM 6*6 MATRIX,AX=B,WHERE A AND B ARE LEAST SQUARES.
D     DIMENSION WT(3)
D     DIMENSION STEST(1)
D     DIMENSION SET(6,6),DELTA(3),XNUM(1),SIGSQ(1),AMAT(6,6),BMAT(6)
     1,A(6,6),B(6)
      DO 10 I=1,MMAX
C     B(I)=DELTA(I)
      DO 10 J=1,NMAX
D10   A(I,J)=SET(I,J)*WT(I)
D     XNUM=XNUM+1.0
      DO 40 IROW=1,6
      DO 40 ICOL=1,6
      DO 40 K=1,MMAX
D     AMAT(IROW,ICOL)=AMAT(IROW,ICOL)+A(K,IROW)*SET(K,ICOL)
      IF(IROW-6)40,30,40
D  30 BMAT(ICOL)  =BMAT(ICOL)  +A(K,ICOL)*B(K)
   40 CONTINUE
      DO 20 I=1,3
D  20 SIGSQ=SIGSQ + (B(I)**2)*WT(I)
C     TEST IN SETUP FOR NSIGSQ GREATER THAN 10-5, IF YES SOLVE,IF NO.CON
C     TINUE
D     IF(SIGSQ-STEST)7C,60,60
   60 CONTINUE
D     IF(XNUM-20.)70,61,61
   61 CONTINUE
      NGOSOL=2
      GO TO 200
   70 CONTINUE
      NGOSOL=1
      GO TO 200
  200 RETURN
      END(1,0,C,0,0,C,1,0,C,1,0,C,C,C,0)
```

```
 CCRECT  CORECTS MEAN ELEMENTS       CHARLES J. DEVINE                    7/01/64       PAGE 1

      SUBROUTINE CORECT(XSOLVE,MEAN,XMEAN ELM,PQRN, XMU            )
C**********              ** DIMENSION  STATEMENTS **              ************
C
D     DIMENSION ELM(7)
D     DIMENSION XMU(1)
D     DIMENSION DPP(3),DPQ(3),DPR(3)
D     DIMENSION XSOLVE(6),XMEAN(1),ELEM(7),ELIPT(7),PQR(3,3),PQRN(3,3)
D     DIMENSION PP(3),PQ(3),PR(3)
C
C                              ***************
C
C     COMPUTE DELTA INCLINATION,DELTA LONG.ASCEND.NODE,DELTA ARGPERIHEL.
C
      DO 50 I=1,7
D 50  ELEM(I)=ELM(I)
      DO 60 I=1,3
      DO 60 J=1,3
D 60  PQR(I,J)=PQRN(I,J)
D     DELP=XSOLVE(2)
D     DELQ=XSOLVE(3)
D     DELR=XSOLVE(4)/ELEM(3)
C
D     OMEGA=ELEM(6)
C     SINOM=SINF(OMEGA)                                          PERIHELN
D     COSOM=COSF(OMEGA)                                          PERIHELN
D     SINI=SINF(ELEM(4))                                         INCLINAT
D     COSI=COSF(ELEM(4))
C                                  BROUWER+CLEM. P.239 FOLLOWING EQUA.
D     DELI=DELP*COSOM-DELQ*SINOM                                 INCLN.
D     DELPI=SINI*((SINOM*DELP+COSOM*DELQ)/(1.+COSI))+DELR
C     ABSIN=ABSF(SINI)
D     CONST=1.0E-16
D     IF(ABSIN-CONST)150,150,155
0150  DELN=0.0
      GO TO 160
0155  SIDELO=DELP*SINOM+DELQ*COSOM
D     DELN=SIDELO/SINI
 160  CONTINUE
D     DELPR=DELPI-DELN
      WRITE OUTPUT TAPE 6,161
 161  FORMAT(1H0,24H  LITTLE  OMEGA  TILTA///)
```

```
 CCRECT  CORECTS MEAN ELEMENTS       CHARLES J. DEVINE                    7/01/64       PAGE 2

      CALL DOUTPT(DELPI,1,1)
C
C
C     ELEM1=A,ELEM2=N,ELEM3=E,ELEM4=I,ELEM5=LON.ASC.,ELEM6=PERIH.,ELEM7=
C    XMEAN AN.
C
C
C     NOW COMPUTE SIX ELLIPTICAL ELEMENTS
C
D     ELIPT(1)=XSOLVE(5)*ELEM(1)                                 SEMIMAJ.
C     ELIPT(2)=0.0                                               MEANMOT.
D     ELIPT(3)=XSOLVE(6)                                         ECCENT.
C     ELIPT(4)=DELI                                              INCLIN.
D     ELIPT(5)=DELN                                              LNGASCN
D     ELIPT(6)=DELPR                                             ARGPERI
D     ELIPT(7)=XSOLVE(1)-DELR                                    MEANANOM
C
C     WRITE OUT PQR,ELEM,XSOLVE,BEFORE CORRECTIONS
C
      WRITE OUTPUT TAPE 6,80
   80 FORMAT(1H ,25H    THIS  IS  PQR  MATRIX///)
      DO 82 I=1,3
D     PP(I)=PQR(1,I)
C     PQ(I)=PQR(2,I)
D  82 PR(I)=PQR(3,I)
      CALL DOUTPT(PP,3,3,PQ,3,3,PR,1,3)
      WRITE OUTPUT TAPE 6,84
   84 FORMAT(1H ,10H    ELEMTS///)
      CALL DOUTPT(ELEM,7,7)
      WRITE OUTPUT TAPE 6,86
   86 FORMAT(1H ,10H    XSOLVE///)
      CALL DOUTPT(XSOLVE,6,6)
C
C     NOW COMPUTE NEW ELEMENTS
C
      DO 100 J=1,7
D 100 ELEM(J)=ELEM(J)+ELIPT(J)
C                   *
C
C     NOW TEST FOR MEAN DAILY MOTION CALC.
C
      GO TO (110,111),MEAN
```

```
 CCRECT  CORECTS MEAN ELEMENTS       CHARLES J. DEVINE                    7/01/64        PAGE 3

  110 CONTINUE
C     ELEM(2)=(1./ELEM(1))*SQRTF(XMU/ELEM(1))
      GO TO 112
C
  111 CONTINUE
C     ELEM(2)=XMEAN
C     ARG=XMU/XMEAN**2
C     EXPON=1./3.
C     ELEM(1)=ARG**EXPON
  112 CONTINUE
C
C     NOW COMPUTE PQRW WHICH IS CORRECTED PQR MATRIX
C
C     SINI= SINF(ELEP(4))
C     COSI= COSF(ELEP(4))
C     SINP= SINF(ELEP(6))
C     COSP= COSF(ELEP(6))
C     SINL= SINF(ELEP(5))
C     COSL= COSF(ELEP(5))
C     PQR(1,1)= COSP*COSL - SINP*SINL*COSI
C     PQR(1,2)= COSP*SINL + SINP*COSL*COSI
C     PQR(1,3)= SINP*SINI
C     PQR(2,1)= -SINP*COSL - COSP*SINL*COSI
C     PQR(2,2)=-SINP*SINL + COSP*COSL*COSI
C     PQR(2,3)= COSP*SINI
C     PQR(3,1)= SINL*SINI
C     PQR(3,2)=-COSL*SINI
C     PQR(3,3)= COSI
C     NOW WRITE OUT CORRECTIONS, CORRECTED VALUES,NEWPQR,ETC.
C
      WRITE OUTPUT TAPE 6,120
  120 FORMAT(1H ,12H    NEW  PQR///)
      DO 122 I=1,3
C     PR(I)=PQR (1,I)
C     PS(I)=PQR (2,I)
C 122 PR(I)=PQR (3,I)
      CALL DOUTPT(PP,3,3,PQ,3,3,PR,3,3)
C
C
      WRITE OUTPUT TAPE 6,125
  125 FORMAT(1H ,27H    ELLIPTICAL  CORRECTIONS///)
      CALL DOUTPT(ELIPT,7,7)



 CCRECT  CORECTS MEAN ELEMENTS       CHARLES J. DEVINE                    7/01/64        PAGE 4

      WRITE OUTPUT TAPE 6,130
  130 FORMAT(1H ,19H    NEW    ELEMENTS///)
      CALL DOUTPT(ELEM,7,7)
C
C
      WRITE OUTPUT TAPE 6,135
  135 FORMAT(1H ,26H    KEPLERS  3 RD  LAW  PU///)
      CALL DOUTPT(XPU,1,1)
      DO 140 I=1,3
      DO 140 J=1,3
C 140 PQRW(I,J)=PQR(I,J)
      DO 141 I=1,7
C 141 ELP(I)=ELEM(I)
      RETURN
      END(1,0,0,0,0,0,0.1,0,0.1,0.0,0.0,0.0)
```

```
 TRANSX TRANSFORMS ELEMENTS TO XYZ,VELOCITY    CHARLES J. DEVINE            7/01/64        PAGE 1

      SUBROUTINE TRANSX(    PQR,DPXYZ,ELEM,XMU)
C     ******          DIMENSION                       STATEMENTS******
C     DIMENSION XMU(1), PXYZ(6)
C     DIMENSION ELEM(7)       ,PQR(3,3),DPXYZ(6)
C                            ***END***
C     SQRXMU=SQRTF(XMU)
C     AM=ELEM(7)
C     XECC=ELEM(3)
C     XA=ELEM(1)
C     XM=ELEM(2)
C     XB=XA*SQRTF(1.-(XECC**2))
C     XASQR=SQRTF(XA)
C     XEC=XM+XECC*SINF(XM)+(((XECC)**2)*SINF(2.*XM))/2.
C     XEN=XEC
C  30 XEN1=XEN+((XM-XEN)+XECC*SINF(XEN))/(1.-XECC*COSF(XEN))
C     DELXEN=ABSF(XEN1-XEN)
C     XTEST=1.0E-15
C     IF (DELXEN-XTEST)50,50,40
C  40 XEN=XEN1
   42 GO TO 30
   50 CONTINUE
C     XE=XEN1
C     COSE=COSF(XE)
C     SINE=SINF(XE)
C     XTEM=COSE-XECC
      DO 60 I=1,3
C  60 DPXYZ(I)=XA*PQR(1,I)*XTEM+XB*PQR(2,I)*SINE
C     RSQR=(DPXYZ(1)**2)+(DPXYZ(2)**2)+(DPXYZ(3)**2)
C     R=SQRTF(RSQR)
C     RASQRT=R*XASQR
      DO 80 J=1,3
      I=J+3
C      PXYZ(I)=(XB*PQR(2,J)*COSE-XA*PQR(1,J)*SINE)/RASQRT
C  80 DPXYZ(I)=PXYZ(I)*SQRXMU
   90 CONTINUE
      RETURN
      END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

```
      SUBROUTINE CERIV(NTAPE,NOBOD,KPOS,     XDS,XDE,DM,XLITE,XMU,AKS,      1/25/65        PAGE 1

      SUBROUTINE CERIV(NTAPE,NOBOD,KPOS,     XDS,XDE,DM,XLITE,XMU,AKS,
     *                 NAM,NREL,XDSA,XH)
CDERIV   COMPUTES ACCELERATION  CHARLES J. DEVINE
C                    ********    COMMENTS    ********
C
C
C             PRINT OPTION FOR ACCELERATION ,XJD IS NAM=1,
C             NO  PRINT REQUIRES NAM=2,GIVING RETURN
C     CERIV READS COMMON, TO OBTAIN POSITION OF PERTURBING PLANETS
C
C
C
C*********COMMON STATEMENTS FOR POSITION, ACCELERATION, VELOCITY, AND TIME*******
C
      DIMENSION DUM1(49966),AZL(1),AZM(1),AYL(1),AYM(1),AXL(1),AXM(1),VZL
     1(1),VZP(1),VYL(1)-VYM(1),VXL(1),VXM(1),ZL(1),ZM(1),YL(1),YM(1),XL(
     211),XM(1),XJDL(1),XJDM(1)
C
C
C***********                  BEGIN          COMMON                      **********
C
C
      COMMON DUM1,AZL,AZM,AYL,AYM,AXL,AXM,,ZL,VZP,VYL,VYM,VXL,VXM,
     1ZL,ZM,YL,YM,XL,XM,XJDL,XJDM
      COMMON HL,HM
C
C****'**                       END          COMMON                        *******
C
C******DIMENSION STATEMENTS FOR DOUBLE PREC. QUANTITIES.                   ******
C
C          **************BEGIN    DIMENSION    STATEMENTS**************
C
D     DIMENSION XCSA(1),     DATE(1/ ,XH(1)
D     DIMENSION POS(3),ACC(3),VEL(3),DM(1C),AKS(1),XLITE(1),XMU(1)
D     DIMENSION XCIT(3,10),RAT( ),RHOA(1 ),R(1 ),XMO(1 )
D     DIMENSION CIREC(3,10),XINDIR(3,10),DIRSUM(3   ),XINSUM(3   )
D     DIMENSION PENTRO(3   ),SOLAR(3)
D     DIMENSION XJD(1) ,XDS(1),XDE(1)
D     DIMENSION R1(1),R2(1),R3(1)
D     DIMENSION C(3,10)
C
D     DIMENSION XJDTBL(9),CTABL(3,10,9)
D     DIMENSION HSTEP(1)
```

```
      SUBROUTINE CERIV(NTAPE,NOBOD,KPOS,     XDS,XDE,DM,XLITE,XMU,AKS,      1/25/65        PAGE 2

C
C**********                   END    DIMENSION                          **********
C
C
C     FIRST DEFINING FUNCTIONS FOR RHO,RCUBE,ETC.
C
D     STACEF(U,V,W)=(U**2)+(V**2)+(W**2)                                  RCUBE
D     CUBEF(U)=U*SQRTF(U)
C
C                         ***END FUNCTION STATEMENTS***
C
C**    SETUP POSITION,VELOCITY, AND TIME FROM COMMON                          **
      XJD(1)=XJDM
      XJD(2)=XJDL
      POS(1)=XM
      POS(4)=XL
      POS(2)=YM
      POS(5)=YL
      POS(3)=ZM
      POS(6)=ZL
      VEL(1)=VXM
      VEL(4)=VXL
      VEL(2)=VYM
      VEL(5)=VYL
      VEL(3,=VZM
      VEL(6)=VZL
C     NOTE KLINE=0,INITIALLY FROM SYSTEM LOADER
      IF(KLINE)201,120,201
C     HERE IF XJDTBL NOT YET FILLED TO 9 POSITIONS
 120  KRTN=1
      HSTEP(1)=HM
      HSTEP(2)=HL
D     XDSA=XJD
 121  GO TO 4
 122  KLINE=KLINE+1
      DO 123 IPLAN=1,10
      DO 123 ICOR=1,3
D123  CTABL(ICOR,IPLAN,KLINE)=C(ICOR,IPLAN)
D     XJDTBL(KLINE)=DATE
      IF(KLINE-9)124,125,125
D124  XDSA=XDSA+HSTEP
      GO TO 121
```

```
      SUBROUTINE DERIV(MTAPE,NOBOD,KPOS,     XDS,XDE,DM,XLITE,XMU,AKS,      1/25/65        PAGE 3

  125 KRTN=2
  201 JLINE=9
0202  IF(XJD-XJDTBL(JLINE))203,205,207
  203 JLINE=JLINE-1
      IF(JLINE)204,204,202
  204 CALL DUMP
  205 DO 206 IPLAN=1,10
      DO 206 ICOR=1,3
0206  C(ICOR,IPLAN)=CTABL(ICOR,IPLAN,JLINE)
D     DATE=XJD
      GO TO 209
  207 CONTINUE
C                 READ PREPARED COORD TAPE
C
C
D     IF(XJD-XDSA) 2,3,2
D    2 XDSA=XDE
     4 READ TAPE MTAPE,DATE(1),DATE(2),((C(ICOR,IPLAN),C(ICOR,IPLAN+10),
     *            ICOR=1,3),IPLAN=1,10)
D     W=DATE-XDSA
D     IF(W) 4,3,5
     5 U= ABSF(W)
      IF(U-15.) 8,8,9
     8 N=XFIXF(U/XH)+1
      DO 6 J=1,N
     6 BACKSPACE MTAPE
      GO TO 4
     9 REWIND MTAPE
      GO TO 4
     3 CONTINUE
  208 GO TO (122,209),KRTN
  209 CONTINUE
C
D     R2=STAGEF(POS(1),POS(2),POS(3))
D     R3=CUBEF(R2)
C
C
C          OPTION TO COMPUTE RELATIVITY CONTRIBUTION
C
      GO TO (20,24),MREL
   20 CONTINUE
      GO TO 40


      SUBROUTINE DERIV(MTAPE,NOBOD,KPOS,     XDS,XDE,DM,XLITE,XMU,AKS,      1/25/65        PAGE 4

   24 CONTINUE
C
C************ COMPUTE SOLAR TERM USING MU AND GRAV CONSTANT FRO
C
C
C     SOLAR TERM
      DO 35 I=1,3
D  35 SOLAR(I)=-XMU*POS(I)/R3
   40 CONTINUE
C     HERE COMPUTE DIRECT AND INDIRECT TERMS
C
      DO 70 ICOR=1,3
D     DIRSUM(ICOR)=0.0
D     XINSUM(ICOR)=0.0
D  70 PERTRB(ICOR)=0.0
      DO 305 IPLAN=1,10
      DO 300 ICOR=1,3
D 300 XDIT(ICOR,IPLAN)=C(ICOR,IPLAN)-POS(ICOR)
D     RA       =STAGEF(C(1,IPLAN),C(2,IPLAN),C(3,IPLAN))
D     RHOA     =STAGEF(XDIT(1,IPLAN),XDIT(2,IPLAN),XDIT(3,IPLAN))
D     R      =CUBEF(RA       )
D     RHO      =CUBEF(RHOA       )
      DO 305 ICOR=1,3
D     DIREC(ICOR,IPLAN)=DM(IPLAN)*(XDIT(ICOR,IPLAN)/RHO       )
D     XINDIR(ICOR,IPLAN)=-DM(IPLAN)*(C(ICOR,IPLAN)/R       )
D     DIRSUM(ICOR       )=DIRSUM(ICOR       )+DIREC(ICOR,IPLAN)
0305  XINSUM(ICOR       )=XINSUM(ICOR       )+XINDIR(ICOR,IPLAN)
      DO 306 ICOR=1,3
D     PERTRB(ICOR       )=DIRSUM(ICOR       )+XINSUM(ICOR          )
0306  ACC(ICOR       )=SOLAR(ICOR)+AKS*PERTRB(ICOR       )
  320 CONTINUE
      AXP=ACC(1)
      AXL=ACC(4)
      AYP=ACC(2)
      AYL=ACC(5)
      AZP=ACC(3)
      AZL=ACC(6)
C     PRINT OPTION
      GO TO (50,500),NAM
   50 CONTINUE
C     PRINTS ON DATE DESIRED
D     IF(XJD-XDS)500,52,52


      SUBROUTINE DERIV(MTAPE,NOBOD,KPOS,     XDS,XDE,DM,XLITE,XMU,AKS,      1/25/65        PAGE 5

C
D  52 IF(XJD-XDE)55,55,500
   55 CONTINUE
   57 CONTINUE
      WRITE OUTPUT TAPE 6,73,XJD
  73  FORMAT(1HO,15H  JULIAN  DATE=F12.2  )
      WRITE OUTPUT TAPE 6,62
   62 FORMAT(    44H  ACCELERATION  COORDINATES  FOR  MAIN  BODY/)
      CALL DOUTPT(ACC,3,3)
  500 RETURN
      END(1,1,0,0,0,0,1,1,0,1,0,0,0,0,0)
```

```
EOSER  END OF  STEP SUBROUTINE  CHARLES J. DEVINE                    7/01/64        PAGE 1

      SUBROUTINE EOSER(TMAX,JIM)
      DIMENSION DUMN(4984 ),T2(1),T1(1)
      COMMON DUMN,T2,T1
D     DIMENSION TSTP(1),TMAX(1)
      TSTP(1)=T1
      TSTP(2)=T2
      JIM=2
D     IF (TMAX-TSTP) 30,30,20
   20 RETURN
   30 WRITE OUTPUT TAPE 6,31,TSTP ,TMAX
   31 FORMAT(1H0,2F9.1,    46H    HOLD  YOUR  HAT,  TMAX  HAS  BEEN  REA
     XCHED////)
      JIM=1
      RETURN
      END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

```
ERRER  KICKS OUT IF FORTSZ ERROR    CHARLES J. DEVINE                7/01/64        PAGE 1

      SUBROUTINE ERRER
      WRITE OUTPUT TAPE 6,10
   10 FORMAT(1H ,71H          YOU  IDIOT,  GOOD  OLD  FORTSZ  HAS  GIVEN
     X  AN  ERROR  RETURN/
     X72H          FOR  THE FOLLOWING  SIMPLE  REASONS,  THAT  IS  EITHE
     XR  ......./
     X47H          ONE    ..X=Y=Z=0  ILLEGAL  CONDITIONS/
     X55H          TWO    ..M  MUST  BE  GREATER  1,LESS THAN 15/
     X51H                   J  GREATER  0  LESS  THAN  OR =M/
     X54H          THREE  ..START  PROC.  FOUND  NO  DIFF  LINE/
     X50H          FOUR   ..NO  DIFF  LINE  VAR.  EQUATIONS/
     X61H          FIVE   ..ILLEGAL  T  STOP  TIME,  NO  EXTRAPOLATION/)
      RETURN
      END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

```
                CALLING SEQUENCE IS CALL FORDV(IFLAG,IFL,TS)                    7/01/64     PAGE 1

                  00001         ENTRY   FORDV
                  00046         ENTRY   SPOT

  TRANSFER VECTOR
00000  266651636271     FORTSZ

00001  0634 00 1 00042  FORDV SXA     XR1,1             SAVE MAIN FORTRAN
00002  0634 00 2 00043        SXA     XR2,2             INDEX REGISTERS
00003  0634 00 4 00044        SXA     XR4,4
00004  0500 00 4 00001        CLA     1,4               STORE ADDRESS OF IFLAG RETURN
00005  0621 00 0 00036        STA     IFLAG
00006  0500 60 4 00002        CLA*    2,4
00007  0771 00 0 00003        ARS     3
00010  0625 00 0 00034        STT     PLACE+3           STORE ADDRESS OF INTERPOLATE
00011  0500 00 4 00003        CLA     3,4
00012  0767 00 0 00022        ALS     18
00013  0622 00 0 00034        STO     PLACE+3           STORE INITIAL JULIAN DATE
00014  0500 00 0 65652        CLA     M
00015  0771 00 0 00022        ARS     18
00016  0601 00 0 65652        STO     M
00017  0500 00 0 65653        CLA     J
00020  0771 00 0 00022        ARS     18
00021  0601 00 0 65653        STO     J
00022  0500 00 0 65654        CLA     N
00023  0771 00 0 00022        ARS     18
00024  0601 00 0 65654        STO     N
00025  0500 00 0 65655        CLA     OPTION
00026  0771 00 0 00022        ARS     18
00027  0601 00 0 65655        STO     OPTION
00030  0074 00 4 00000        TSX     $FORTSZ,4
00031  0 00060 0 00052  PLACE PZE     DER,,EOS
00032  0 00000 0 00054        PZE     PLIST
00033  0020 00 0 00062        TRA     ERR
00034  0 00000 0 00056        PZE     TSTOP,**,**
00035  0 00000 0 00000        PZE     0
00036  0661 00 0 00000  IFLAG STO     **
00037  0634 00 1 00046  SAVEF SXA     XR1,1             SAVE FORTSZ INDEX REGISTERS
00040  0634 00 2 00047        SXA     XR2,2
00041  0634 00 4 00050        SXA     XR4,4
00042  0774 00 1 00000    XR1 AXT     **,1              RESTORE MAIN FORTRAN
00043  0774 00 2 00000    XR2 AXT     **,2              INDEX REGISTERS
00044  0774 00 4 00000    XR4 AXT     **,4
```

```
                CALLING SEQUENCE IS CALL FORDV(IFLAG,IFL,TS)                    7/01/64     PAGE 2

00045  0020 00 4 00004        TRA     4,4               RETURN TO MAIN
00046  0774 00 1 00000    XR1 AXT     **,1              RESTORE FORTSZ
00047  0774 00 2 00000    XR2 AXT     **,2              INDEX REGISTERS
00050  0774 00 4 00000    XR4 AXT     **,4
00051  0020 00 4 00001        TRA     1,4               RETURN TO FORTSZ
00052  0500 00 0 00064    DER CLA     =1817             SET IFLAG
00053  0020 00 0 00036        TRA     IFLAG             SET AND RESTORE XR5, GO TO MAIN
00054  0443 00 0 65666  RLIST DLD     H                 COMPUTE STEP SIZE
00055  0020 00 4 00001        TRA     1,4               RETURN TO FORTSZ
00056  0500 00 0 00065  TSTOP CLA     =2817             SET AND RESTORE XR5, GO TO MAIN
00057  0020 00 0 00036        TRA     IFLAG
00060  0500 00 0 00066    EOS CLA     =3817             SET AND RESTORE XR5, GO TO MAIN
00061  0020 00 0 00036        TRA     IFLAG
00062  0500 00 0 00067    ERR CLA     =4817             SET AND RESTORE XR5, GO TO MAIN
00063  0020 00 0 00036        TRA     IFLAG             RETURN POINT FROM MAIN
                00046   SPOT SYN     XR4
              065652 COMMON BOOL    65652
               65652      M EQU     COMMON
               65653      J EQU     M+1
               65654      N EQU     M+2
               65655 OPTION EQU     M+3
               65656  CTAPE EQU     M+4
               65657      S EQU     M+5
               65660     ES EQU     M+6
               65666      H EQU     M+12
                         END

  LITERALS
00064  0000010000000
00065  0000020000000
00066  0000030000000
00067  0000040000000
```

```
STPRG2                                                          7/01/64        PAGE 1

      SUBROUTINE STPRG2(AP,FP,SL,NA,MTA,SDIN,SCOUT,CDA,NINA,INCLTA,KPRINT
     *                                                                 T)
C
C     AP=MXN INPUT
C     FP=F VECTOR
C     SL=SUM OF SQUARES
C     N=INPUT SIZE
C     MT=TOTAL NO OF POINTS
C     SDIN  =  IN THRESHOLD FOR ABSF(COEFF/(S.D. OF COEFF))
C     SCOUT = OUT THRESHOLD FOR ABSF(COEFF/(S.D. OF COEFF))
C
C             WHEN F TESTS ARE TO BE USED FIN
C             SHOULD EXCEED FOUT AND FP AND SL MUST
C             CONTAIN LEGITIMATE DATA.
C             IF FIN=0. THEN THE F TESTS WILL BE
C             SKIPPED AND NO TESTS OF THE CONTENTS
C             OF FP AND SL WILL BE MADE.
C     CD=DIAGONAL COEFFICIENT
C     NIN= NO. OF PARAMETERS IN FINAL SOLUTION
C
C             THE ARRAY INCLT(I) INDICATES THE STATUS
C             OF EACH PARAMETER AS FOLLOWS-
C                    +1         PARAMETER IS INCLUDED IN SOLUTION.
C                    -1         PARAMETER REJECTED BY DIAGONAL TEST.
C                    -2         PARAMETER REJECTED BY F TEST.
C
C     KPRINT = 0   NO PRINTING
C            = 1   PRINT SUMMARY, LAST STEP ONLY
C            = 2   PRINT SUMMARY, EACH STEP
C            = 3   FULL PRINTING
C
C     A=WORKING AREA
C     CHANGE TO COMMON DUMMY (XXXX),A(2,,21) TO SAVE 441*2 LOC
C
      DIMENSION A( 7, 7),AP( 6, 6),FP( 6)
      DIMENSION B( 61),INOUT( 7),INCUTA( 6)
      DIMENSION BCD(,2)
      KPR=KPRINT
      N=NA
      MT=MTA
      FIN=SDIN**2
```

```
STPRG2                                                          7/01/64        PAGE 2

      FOUT= SCOUT**2
      CD=CDA
      NP1=N+1
      DO 5 I=1,N
      A(I,NP1)=FP(I)
      DO 5 J=1,N
    5 A(I,J)=AP(I,J)
      A(NP1,NP1)=SL
      INCUT(1)=-1
      NIN=0
      NCOUNT=N+4
      DO 10 K=1,N
      I=K+1
      INCUT(I)=-1
      B(K)=A(K,K)*CD
      DO 10 J=1,K
   10 A(I,J)=A(J,I)
C                              ***BEGIN OUTPUT***
      IF(KPR) 400,400,401
  401 WRITE OUTPUT TAPE 6,1000
 1000 FORMAT(1H1,4CX,6HSTPRG2,10X
     *,27HSTEPWISE REGRESSION PROGRAM)
      WRITE OUTPUT TAPE 6,1002,N,MT,SDIN,SCOUT,CD
 1002 FORMAT(1H0,9X,1HN,4X,6HMTOTAL,11X,4HSDIN,1CX,5HSDOUT
     *,11X,4HDIAG/1H0,2110,1P3E15.6)
      IF(KPR-3) 400,402,400
  402 DO 15 I=1,N
   15 WRITE OUTPUT TAPE 6,902,I,B(I)
  902 FORMAT (1H ,2HB(,I2,2H)=,E16.8)
  400 CONTINUE
C                              ***END OUTPUT***
      U1=0.0
      U2=0.0
      K=0
C                              BEGIN MAIN LOOP
   20 CONTINUE
C                              ***BEGIN OUTPUT***
      IF(KPR-3) 406,405,406
  405 CONTINUE
      WRITE OUTPUT TAPE 6,903,U1,U2,I1,I2,K,NCOUNT,NIN
  903 FORMAT (1H0,3HU1=,E16.8,4HU2= ,E16.8,4HI1= ,I2,4HI2= ,I2,3HK= ,I2,
     19HN COUNT= ,I5,5HNIN= ,I2)
```

```
STPRG2                                                    7/01/64    PAGE 3

      DO 25 J=1,NP1
      WRITE OUTPUT TAPE 6,904,J
  904 FORMAT(7HOCOLUMN,I4/1X)
      CALL DOUTPT(A(1,J) , NP1 , 441)
   25 CONTINUE
  406 CONTINUE
C                               ***END OUTPUT***
      IF(FIN) 200,200,100
C                               BEGIN PIVOT SELECTION (FIN NOT 0.)
  100 FMT=MT-NIN
C                               ***BEGIN OUTPUT***
      IF(KPR-2) 404,403,403
  403 SDDATA=SQRTF(A(NP1,NP1)/FMT)
      FMT1=FMT-1.
      WRITE OUTPUT TAPE 6,1003,NIN,A(NP1,NP1),SDDATA
 1003 FORMAT(13HONO. OF COEFFS IN REGRESSION =
     *I3,5X,26HSUM OF SQUARED RESIDUALS =1PE13.5,5X
     *,14HS.D. OF DATA =1PE13.5
     *///18X,20HCOEFFS IN REGRESSION,55X,
     *24HCOEFFS NOT IN REGRESSION
     *// 6H INDEX,14X,5HCOEFF12X,4HS.D.,6X,10HCOEFF/S.D.,33X
     *  ,5HINDEX,3X,22HPREDICTED (COEFF/S.D.)/1X)
  404 CONTINUE
C                               ***END OUTPUT***
      IF(A(NP1,NP1)) 900,900,40
   40 U1=0.17E+39
      U2=0.0
      DO 50 I=1,N
      U=A(I,NP1)*A(I,NP1)/A(I,I)
      IF(INOUT(I))45,43,43
   43 CONTINUE
C                               ***BEGIN OUTPUT***
      IF(KPR-2) 408,407,407
  407 SD=SQRTF(A(I,I))*SDDATA
      RATIO=A(I,NP1)/SD
      WRITE OUTPUT TAPE 6,1004,I,A(I,NP1),SD,RATIO
 1004 FORMAT(1X,I5,,2PE19.7,2E16.4)
  408 CONTINUE
C                               ***END OUTPUT***
      IF(U-U1)44,50,50
   44 U1=U
      I1=I
```

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STPRG2                                                    7/01/64    PAGE 4

      GO TO 50
C                               DIAGONAL TEST
   45 IF(A(I,I)-B(I)) 101,101,46
  101 INOUT(I)=-1
C                               ***BEGIN OUTPUT***
      IF(KPR-2) 501,500,500
  500 WRITE OUTPUT TAPE 6,1007,I
 1007 FORMAT(I95,10X,9HDEPENDENT)
  501 CONTINUE
C                               ***END OUTPUT***
      GO TO 50
   46 INOUT(I)=-2
C                               ***BEGIN OUTPUT***
      IF(KPR-2) 410,409,409
  409 RATIO = SQRTF(U*(FMT1)/(A(NP1,NP1) - U))
      WRITE OUTPUT TAPE 6,1005,I,RATIO
 1005 FORMAT(I95,1PE19.4)
  410 CONTINUE
C                               ***END OUTPUT***
      IF(U-U2)50,50,47
   47 U2=U
      I2=I
   50 CONTINUE
      IF(NCOUNT)52,52,55
   55 NCOUNT=NCOUNT-1
      IF(U1-0.17E+39)58,52,52
   58 IF(U1*FMT/A(NP1,NP1)-FOUT)59,52,52
   59 K=I1
      GO TO 65
   52 IF ( U2 ) 900,900,54
   54 IF(A(NP1,NP1)-U2)60,60,654
  654 IF(U2*(FMT-1.0)/(A(NP1,NP1)-U2)-FIN)900,60,60
   60 K=I2
      INOUT(K)= +1
      GO TO 67
C                               END PIVOT SELECTION (FIN NOT 0.)
C
C                               BEGIN PIVOT SELECTION (FIN=0.)
  200 SIZE=0.
      DO 201 I=1,N
      IF(INOUT(I)) 202,201,201
  202 TEST=A(I,I)/B(I)
```

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STPRG2                                                          7/01/64      PAGE 5

      IF(TEST-SIZE) 201,201,205
  205 SIZE=TEST
      K=I
  201 CONTINUE
C                                 DIAGONAL TEST
      IF(SIZE-1.) 900,900,65
C                                 END PIVOT SELECTION (FIN=0.)
C
C                                 BEGIN JORDAN PIVOT
   65 INOUT(K)=-INOUT(K)
   67 NIN=NIN+INOUT(K)
C                                  ***BEGIN OUTPUT***
      IF(KPR-2) 412,411,411
  411 IF(INOUT(K)) 415,415,414
B 414 BCD(1)=6031456351 46
B     BCD(2)=246423314527
      GO TO 416
B 415 BCD(1)=606060602425
B     BCD(2)=432563314527
  416 WRITE OUTPUT TAPE 6,1006,BCD,K
 1006 FORMAT(1H0,44X,2A6,10H COEFF NO.I4)
  412 CONTINUE
C                                  ***END OUTPUT***
D     A(K,K)=1.0/A(K,K)
      DO 70 J=1,NP1
      IF(J-K)66,70,66
D   66 A(K,J)=A(K,K)*A(K,J)
D     A(J,J)=A(J,J)-A(J,K)*A(K,J)
      IF(A(J,J))68,70,70
D   68 A(J,J)=0.0
   70 CONTINUE
      DO 76 I=1,N
      IF(I-K)71,76,71
   71 IP1=I+1
      DO 75 J=IP1,NP1
      IF(J-K)72,75,72
D  72 A(I,J)=A(I,J)-A(I,K)*A(K,J)
      IF(INOUT(I) * INOUT(J))73,73,74
D  73 A(J,I)=-A(I,J)
      GO TO 75
D  74 A(J,I)=A(I,J)
   75 CONTINUE
```

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STPRG2                                                          7/01/64      PAGE 6

   76 CONTINUE
      DO 90 I=1,NP1
      IF(INOUT(I) * INOUT(K))85,85,80
D  80 A(I,K)=A(K,I)
      GO TO 90
D  85 A(I,K)=-A(K,I)
   90 CONTINUE
C                                 END JORDAN PIVOT
      GO TO 20
C                                 END MAIN LOOP
C
C                                COMPUTATION FINISHED
  900 CONTINUE
      IF(KPR-1) 418,417,418
C                                 REPEAT LAST PASS TO OBTAIN OUTPUT
  417 KPR=2
      GO TO 20
  418 CONTINUE
C                                 BEGIN-STORE FINAL RESULTS
      DO 920 I=1,N
      IF(INOUT(I))911,912,912
D 911 FP(I)=0.0
      GO TO 915
D 912 FP(I)=A(I,NP1)
  915 DO 920 J=1,N
      IF(INOUT(I))916,917,917
D 916 AP(I,J)=0.0
      GO TO 920
  917 IF(INOUT(J))916,918,918
D 918 AP(I,J)=A(I,J)
  920 CONTINUE
D     SL=A(NP1,NP1)
      NINA=NIN
      DO 300 I=1,N
  300 INOUTA(I)=INOUT(I)
C                                 END-STORE FINAL RESULTS
      RETURN
      END(1,0,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

```
      SUBROUTINE ELEMTS(COSOB,SINOB,CPOS,XMU,OPQR,ELEM,MEAN,XMEAN)          7/01/64        PAGE 1

      SUBROUTINE ELEMTS(COSOB,SINOB,CPOS,XMU,OPQR,ELEM,MEAN,XMEAN)
CELEMTS
C     PROGRAMMER--N. BLOCK(JPL)--1964 FEB 27
D     DIMENSION XMEAN(1)
D     DIMENSION CPOS(6),POS(6),VEL(6),XMU(1),PQR1(3,3),PQR(3,3),ELEM(7)
D     DIMENSION COSOB(1),SINOB(1)
D     DIMENSION TEMP1(1),TEMP2(1)
D     DIMENSION OPQR(3,3)
      EQUIVALENCE (POS(4),VEL(1))
C     NOTE THAT XMU=(GAUSS**2)*(1.+XMASS)
D     SQRTMU=SQRTF(XMU)
      DO 10 ICOR=1,3
C     POS(ICOR  )=CPOS(ICOR  )
D10   POS(ICOR+3)=CPOS(ICOR+3)/SQRTMU
D     RSQR=POS(1)**2+POS(2)**2+POS(3)**2
D     GSQR=VEL(1)**2+VEL(2)**2+VEL(3)**2
D     H    =POS(1)*VEL(1)+POS(2)*VEL(2)+POS(3)*VEL(3)
D     R=SQRTF(RSQR)
D     RECA=2.0/R-GSQR
D     A=1.0/RECA
D     SQRTA=SQRTF(A)
C     ATHRH=A*SQRTA
D     XN=SQRTMU/ATHRH
      GO TO (49,48),MEAN
D  48 A=(XMU/XMEAN**2)**(1./3.)
D     XN=XMEAN
   49 CONTINUE
D     ESINE=H/SQRTA
D     ECOSE=R*GSQR-1.0
D     ECC=ARCTN(ESINE,ECOSE)
C     SINE=SINF(ECC)
D     COSE=COSF(ECC)
C     E=ESINE*SINE+ECOSE*COSE
C     P=A*SQRTF(1.0-E**2)
D     FK1=COSE/R
C     FK2=-SQRTA*SINE
D     FK3=(A*SINE)/(R*P)
D     FK4=(ATHRH*(COSE-E))/P
      DO 11 ICOR=1,3
D     PQR1(ICOR,1)=FK1*POS(ICOR)+FK2*VEL(ICOR)
D11   PQR1(ICOR,2)=FK3*POS(ICOR)+FK4*VEL(ICOR)
      DO 12 ICOR=1,3
```

```
      SUBROUTINE ELEMTS(COSOB,SINOB,CPOS,XMU,OPQR,ELEM,MEAN,XMEAN)          7/01/64        PAGE 2

      I1=XMODF(ICOR  ,3)+1
      I2=XMODF(ICOR+1,3)+1
D12   PQR1(ICOR,3)=PQR1(I1,1)*PQR1(I2,2)-PQR1(I2,1)*PQR1(I1,2)
      DO 13 ICOL=1,3
C     PQR(1,ICOL)=PQR1(1,ICOL)
C     PQR(2,ICOL)=+COSOB*PQR1(2,ICOL)+SINOB*PQR1(3,ICOL)
D13   PQR(3,ICOL)=-SINOB*PQR1(2,ICOL)+COSOB*PQR1(3,ICOL)
D     TEMP1=PQR(3,1)
C     TEMP2=PQR(3,2)
C     OMEGA=ARCTN(TEMP1,TEMP2)
D     COSOM=COSF(OMEGA)
D     SINOM=SINF(OMEGA)
D     SINI=PQR(3,1)*SINOM+PQR(3,2)*COSOM
C     COSI=PQR(3,3)
D     XI=ARCTN(SINI,COSI)
D     COSNOD=+COSOM*PQR(1,1)-SINOM*PQR(1,2)
D     SINNOD=+COSOM*PQR(2,1)-SINOM*PQR(2,2)
C     XNOD=ARCTN(SINNOD,COSNOD)
D     XM=ECC-ESINE
      DO 14 IROW=1,3
      DO 14 ICOL=1,3
D14   OPQR(IROW,ICOL)=PQR(IROW,ICOL)
D     ELEM(1)=A
D     ELEM(2)=XN
D     ELEM(3)=E
D     ELEM(4)=XI
C     ELEM(5)=XNOD
D     ELEM(6)=OMEGA
D     ELEM(7)=XM
      RETURN
      END(1,0,C,0,0,C,1,0,C,1,0,0,0,C,0)
```

```
 ARCTN                                                    7/01/64        PAGE 1

      FUNCTION  ARCTN(Y,X)
C     FUNCTION ARCTN(Y,X)  DOUBLE PRECISION
D     PI=3.14159265358979
      IF (X) 68,69,70
 68   IF (Y) 69,  ,70
C  69 ARCTN=+1.  *PI
      GO TO
D  70 ARC    2.0*PI
        10H
D71      CTN=0.0
      GO TO 108
   .0  ARCTN=ATANF(Y/X)
 104  IF (X) 105,106,106
D 105 ARCTN=ARCTN+PI
 106  IF (ARCTN) 107,108,108
D 107 ARCTN=ARCTN+2.0*PI
 108  RETURN
      END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

```
 SPHER                                                    1/25/65        PAGE 1

C     SPECIFIED AND PROGRAMMED BY N.BLOCK (JPL)
      SUBROUTINE SPHER(X,Y,Z,RHO,XLON,XLAT)
C     DIMENSION X(1),Y(1),Z(1),XLON(1),XLAT(1),R(1),RHO(1)
D     PI=3.14159265358979
D     HALFPI=PI*0.50
D     R=X**2+Y**2
D     RHO = SQRTF(R+Z**2)
D     IF(R) 3,3,2
D2    XLON= ARCTN(Y,X)
D     R=SQRTF(R)
D     XLAT= ARCTN(Z,R)
      IF(XLAT-1.6)25,24,24
D24   XLAT=XLAT-2.0*PI
 25   RETURN
D3    XLON =0.0
D     XLAT=SIGNF(HALFPI,Z)
      RETURN
      END(1,1,0,0,0,0,0,1,1,0,1,0,0,0,0)
```

```
 OBLIQ                                                    1/25/65        PAGE 1

C     SPECIFIED AND PROGRAMMED BY N.BLOCK (JPL)
      SUBROUTINE OBLIQ(XJD,EPSLN)
D     T=(XJD-2415020.0)/36525.0
D     EPSLN=(((+1.81E-3*T-5.9E-3)*T-46.845)*T+84428.26)/1296000.0
      RETURN
      END(1,1,0,0,0,0,0,1,1,0,0,0,0,0,0)
```

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