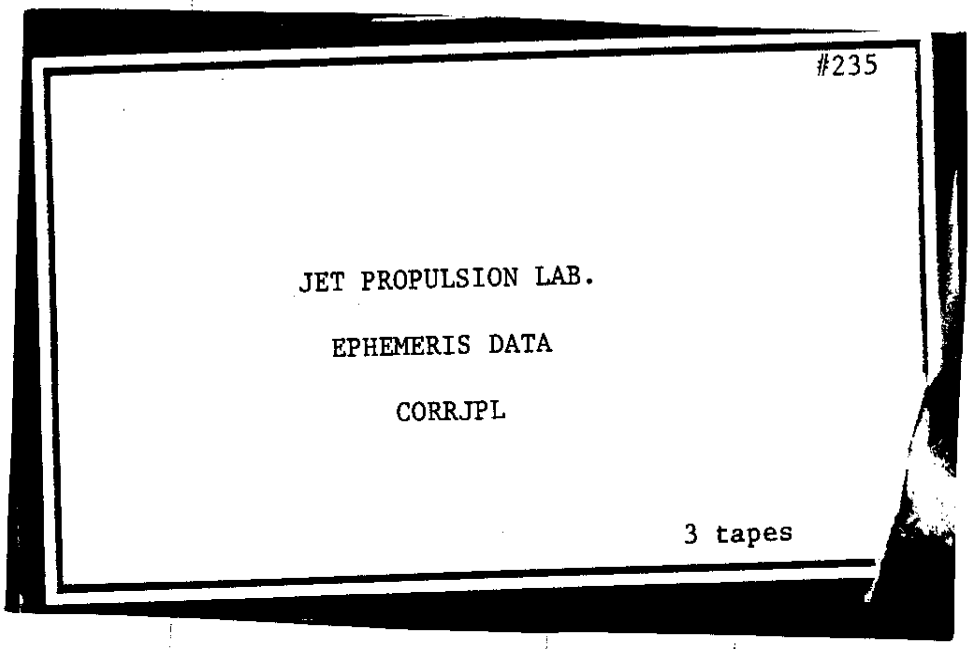
#235
JET PROPULSION LAB.
EPHEMERIS DATA
CORRJPL
3 tapes

Table of Contents

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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP's).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC INFORMATION SYSTEM:

http://nssdc.gsfc.nasa.gov/nmc/

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

a. Associated Documents To find associated documents you will need to know the document ID number and then click here. http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/

b. Core Catalog Materials

REQUEST AGENT	RASH NO.	ACQ. AGENT
PAR	RB4572	CDW

JET PROPULSION LAB.

EPHEMERIS DATA

CORRJPL

This data set consists of 3 tapes containing Ephemeris information for all the planets and the Moon. The tapes were created on a UNIVAC 1108 computer and are 800 BPI, 7-track, binary with one file per tape.

The format for the data can be found on page 23 of the 'JPL Development Ephemeris Number 69, Technical Report 32-1465', which is included in this data set catalog.

The first record of each tape is a BCD header describing the general nature of the information on the tape. The first and last words of each record are control words which are not mentioned in the format.

The time spans for the tapes are as follows:

D#	C#	TIME SPAN
D-11597	C-09569	6/24/52 - 4/20/70
D-11598	C-09570	3/05/70 - 4/03/84
D-11599	C-09571	1/13/84 - 11/30/99

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Report 32-1465

JPL Development Ephemeris Number 69

Douglas A. O'Handley
Douglas B. Holdridge
William G. Melbourne
J. Derral Mulholland

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
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PASADENA, CALIFORNIA

December 15, 1969

Prepared Under Contract No. NAS 7-100
National Aeronautics and Space Administration

Preface

The work described in this report was performed by the Mission Analysis Division of the Jet Propulsion Laboratory.

Acknowledgment

The system of computer programs used in this research effort were formulated by Dr. Charles C. Lawson of JPL. The system analysis and coding was carried out by the Federal Systems Division West of International Business Machines Corporation.

In particular, two individuals Rex E. Reed and Dan Dannenfeldt of IBM are singled out for their interest and dedication in the successful implementation of the system of programs to improve the knowledge of the locations of planets in the solar system.

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Figures (contd)

Abstract

The third issue of JPL Ephemeris Tapes is described, and is designated JPL Development Ephemeris No. 69 (DE 69). It is a special-purpose ephemeris that covers a short time span and does not replace DE 19 (Ref. 1) as the JPL export ephemeris. These tapes carry the positions and velocities of the planets and of the moon, nutations and nutation rates in longitude and obliquity, and second and fourth modified differences of all these quantities for the interval from October 28, 1961 to January 23, 1976. The description includes discussions of the improvements in the Lunar Ephemeris and the planetary ephemerides made subsequently to the second issue of the JPL Ephemeris Tapes (DE 19). These tapes will be distributed through the NASA Computer Software Management and Information Center (COSMIC).

JPL Development Ephemeris Number 69

I. Introduction

The JPL Development Ephemeris 69 described in this report is the third release from the JPL Ephemeris Tape System. It is a special purpose ephemeris that covers a short time span and will not replace DE 19 (Ref. 1) as the JPL Export Ephemeris. For users who need planetary positions before 1962 and after 1976, the DE 19 ephemeris is still available.

Tape	Julian date (Calendar date)	to	Julian date (Calendar date)
DE 69	243 7600.5		244 2800.5
	(1961 Oct. 28.0)		(1976 Jan. 23.0)

This ephemeris is the first gravitationally consistent ephemeris computed and exported from JPL. The computations are carried out by a system of programs referred to as the Solar System Data Processing System (SSDPS). The numerical integration, the observational data set, and comparison of these data with the simultaneous integrations of the nine planets are discussed.

The lunar data in DE 69 were not produced by the SSDPS integration, but are nonetheless quite different from those of DE 19. These data are the result of a composite process that included a long-span numerical integration of the moon only. The construction process is discussed in some detail in the following section.

Planetary data are heliocentric and are expressed in astronomical units (AU) and AU/day, and lunar data are geocentric and expressed in fictitious units called "earth radii" (R_{em}) and "earth radii"/day. Translation between the geocenter and the earth-moon barycenter is accomplished using the earth/moon mass ratio μ^{-1}. The values of these parameters currently recommended for most satisfactory use of DE 69 are (Ref. 2) as follows:

$$\text{AU} = 149{,}597{,}893.0 \quad \text{km}$$

$$R_{em} = 6378.1492 \text{ km}$$

$$\mu^{-1} = 81.301$$

Master copies of DE 19 and DE 69 have been supplied to COSMIC, University of Georgia, which will serve as the primary distribution point for these data.

II. Lunar Ephemeris

The requirements of high-precision analysis of spacecraft data and the accurate determination of the coordinates of DSN tracking stations have been major motivating factors in the persistent efforts to improve the quality of the JPL lunar ephemerides. Residual characteristics have sometimes suggested problem areas and potential improvement techniques. It is just such a situation that led to the development of JPL Lunar Ephemeris Number 16.

A. Background

It has been noted for some time that the tracking station locations derived from analyses of planetary spacecraft data differ systematically from the locations of the same stations based on data from lunar missions, the differences being on the order of tens of meters. This circumstance has been difficult to understand. If it were attributed to errors in the Lunar Theory, or in its fitting to observations, the size and nature of the error would make it easily observable. On the other hand, the proliferation of coordinate systems in astronomy presents a more subtle pitfall. Van Flandern (Ref. 3) pointed out that, for the fitting of the Lunar Theory to observations, E. W. Brown determined the equinox from his own reference stars. Thus, the reference direction of the theory is unique to that theory; it is apparently very near to Newcomb's equinox. To be consistent with the planetary ephemerides based on modern observations, the lunar ephemeris should be referred to the FK4 coordinate system (Ref. 4). It seems safe to assume that virtually all users of the JPL Ephemeris Tape System have, from its inception, tacitly assumed that this was the case. This must be regarded as an error in the precepts for application of the ephemeris rather than in the ephemeral data themselves. Nonetheless, the transformation to the FK4 model should be done in the Ephemeris Tape System, if the necessary parameters are known.

Van Flandern has, in fact, undertaken to solve for the transformation between Brown's equinox and that of the FK4, as a part of a more general study to correct the lunar elements. A very preliminary discussion of this effort is given in Ref. 3, and a complete solution is presented in Ref. 5. These latter results were not the final results of the work; some of the values have changed subsequently, but the equinox shift has remained fairly stable throughout the work. However, the coupling between parameters is such that the equinox shift so derived should be applied as a part of the overall system.

B. Transforming the JPL Ephemeris

This entire question will vanish when the lunar ephemeris is based on a numerical integration fit to real observations referred to the FK4 frame. This work is underway, but may not be expected to produce operationally useful results for some time yet. Nonetheless, previously reported work (e.g., Ref. 6) has indicated the urgent need for an integrated lunar ephemeris for operational use, and it seems desirable that it be on the FK4 system if possible.

The problems involved in producing long-interval integrations of the lunar motion were discussed in Ref. 7, where the effects not modelled in a PLOD integration (Ref. 8) were described, as was a theoretical ephemeris (LE 13) which had these effects removed analytically. In attempting to place such an ephemeris on the FK4 system, no alternative currently exists but the application of the results in Ref. 5. The corresponding expressions to be applied to a theoretical ephemeris were supplied by Van Flandern and these were applied to LE 12. The effect of the equinox shift was to change the mean longitude by an amount

$$\Delta L = -0''.8746 + 0''.732T$$

T in centuries from 1950. It may be presumed that this ephemeris (LE 14) is on the FK4 system, contains none of the effects known to be unmodelled in PLOD, and suffers the gravitational defects of the Brown theory. This was used as a source theory to which a PLOD numerical integration was fit over the interval 1950–1970. The statistics of the fit are given in Table 1, where the ephemeris is designated LE 15. This ephemeris does not have the gravitational defects of the Brown theory, but cannot be used directly because of the effects unmodelled in the integration, the effects that were removed analytically in the construction of LE 12. Thus, it was necessary to replace them; this was done by analytic modifications applied to the coordinates of LE 15. This

Table 1. Statistics of the fit of LE 15 to LE 14

Coordinate	δr	$r \cos \beta \, \delta\lambda$	$r \, \delta\beta$
Mean deviation	+64.2 m	−0.2 m	−4.8 m
Standard deviation	223.8	211.4	249.5
Extremal deviation	+851.4	+757.7	−758.8

last step in the sequence was designated LE 16[1], which should fit Van Flandern's version of the Brown theory in the same way that LE 15 fits LE 14. A sample comparison of LE 16 with LE 4 (Ref. 9), which is in DE 19, is given in Fig 1.

Because of the interest in the station location problem, and of the insensitivity of the *Mariner* trajectory to such small changes in the lunar ephemeris, LE 16 was incorporated into DE 69, the operational ephemeris for *Mariner* Mars 1969 pre-encounter activities. It is not yet clear how much of an improvement the equinox shift has produced, but station location analyses by other JPL investigators (Refs. 10 and 11) indicate that spacecraft trajectory residuals are reduced by use of LE 16. Although consistency between lunar and planetary mission results has not yet been achieved unambiguously, the disparities are reduced in most cases. The initial tests of the application of real observations of the moon have also been encouraging. The lunar starting conditions for a ten-body integration were taken from LE 16 and, while the integration and comparison with observations covered only 100 days, an equinox error would appear as a roughly constant bias in right ascension. None was observed as large as a few tenths of an arc second.

[1]This discussion presents some insight into the proliferation of LE and DE numbers in the ephemeris development effort. Each distinct ephemeris receives a number, to minimize possible confusion. In this case, LE 12, 14 and 15 will never be used operationally, but they were necessary steps in the construction of LE 16.

III. Planetary Ephemeris

A. Numerical Integration

The current JPL Export Ephemeris, DE 19 (Ref. 1), consists of nine successive single-body integrations. The relativistic differential equations of motion used in this integration were based upon the Schwarzschild line element which is given in Brouwer and Clemence (Ref. 12).

The SSDPS was completed late in 1967. It is a series of programs that is used to integrate numerically the motions of the nine planets simultaneously, compare

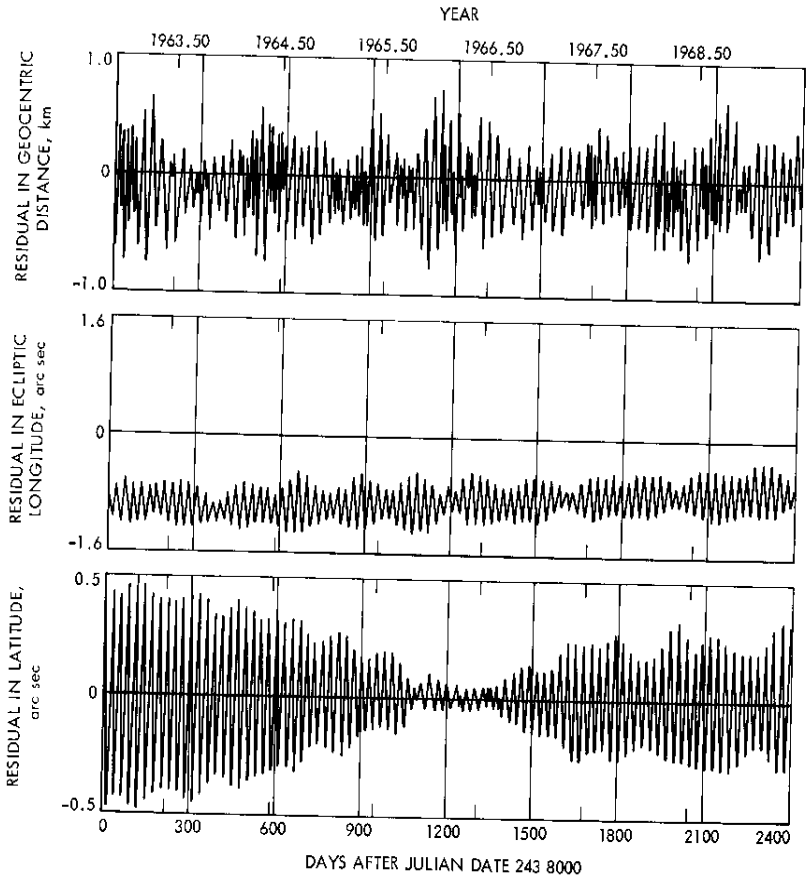

Fig. 1. Effects of TVF corrections—LE 16–LE 4.

with optical, radar, and spacecraft observations, form partial derivatives with respect to the orbital elements and additional parameters, and provide corrections to the initial set of osculating elements and parameters.

The heliocentric equations of motion are:

$$\ddot{\underline{r}}_j = -(w_o + w_j)\,\underline{u}_j - \sum_{\substack{i=1,\,10 \\ i \neq j}} w_i(\underline{v}_{ij} - \underline{u}_i) + \underline{R}\,(\underline{r}_j, \dot{\underline{r}}_j, m_j)$$

where

$$\underline{s}_{ij} = \underline{r}_j - \underline{r}_i$$

$$\underline{u}_j = r_j^{-3}\,\underline{r}_j$$

$$\underline{v}_{ij} = s_{ij}^{-3}\,\underline{s}_{ij}$$

$$w_j = Gm_j \quad \text{where } G = (0.01720\ 20989\ 5)^2$$

$$w_o = G$$

The function $\underline{R}$ is used to introduce the effects associated with general relativity.

In order to be compatible with the form of the relativity metric used in the double-precision orbit determination program (DPODP), the SSDPS used the "Robertson" form of the metric (Ref. 13). The Robertson parameters β and γ are now input quantities with the nominal values of unity. With these values, the equations reduce to the isotropic form of the metric.

The vector transformation, relating standard form coordinates r to isotropic coordinates ρ, is

$$r = \rho\left(1 + \frac{m}{2\rho}\right)^2.$$

This transformation, together with its first time derivative, must be used to convert the new isotropic coordinates and velocity components in DE 69 to the standard Schwarzschild metric used in DE 19. Here, m is the Schwarzschild radius.

$$m = 1.47\ \text{km}$$

The values of the Sun/planet mass ratios have been altered from those appropriate for DE 19. In DE 19 the planetary masses were identical with the internationally adopted set [(IAU), 1964] and are given in the first column of Table 2. The planetary masses used in the 60-year integration reflect more recent determinations (Ref. 2).

Table 2. Reciprocal planetary masses

Planet	IAU (1964)	JPL (1969)
Mercury	6 000 000	5 983 000
Venus	408 000	408 522
Earth-moon	329 390	328 900.1
Mars	3 093 500	3 098 700
Jupiter	1 047.355	1 047.3908
Saturn	3 501.6	3 499.2
Uranus	22 869	22 930
Neptune	19 314	19 260
Pluto	360 000	1 812 000
Sun = 1.0.		

The mass of Mercury is derived from analysis of radar observations of Venus. The mass values used for Venus, Earth-moon and Mars are based on radio tracking data from the Mariner, Ranger and Surveyor spacecraft series. The masses of Jupiter, Saturn, and Uranus result from the rediscussion by Mulholland (Ref. 14). The masses of Neptune and Pluto result from more recent work by Gill and Gault (Ref. 15) and Duncombe, et al., respectively (Ref. 16). These masses are given in column 2 of Table 2.

The epoch conditions for DE 69 are referred to JD 244 0800.5, 0^hET, August 2, 1970. This date has been chosen as the standard 400-day date in 1970 which will be used by the ephemeris group of representatives from NASA, the U. S. Naval Weapons Laboratory (NWL), the U. S. Naval Observatory (USNO), and JPL.

B. Observation Set

Optical observations from 1910–1968 from the Six and Nine Inch Transit Circles of the USNO have been collected and placed in a uniform format on punched cards (Ref. 17). The collection of the data over the period 1911–1949 was made by C. Oesterwinter (NWL), Dahlgren, Virginia. These observations were initially compared with DE 28 (Ref. 18). The mispunched cards and obvious printing errors were found and corrected. The final optical data set of over 34,000 observations covering the 60-year period is given in Table 3.

Radar range data from various radar sites have been collected. The collection of these data has been a joint effort by MIT-Lincoln Laboratory and JPL.

Table 3. Transit circle observations

Planet	USNO transit circle	Period	Number of observations	
			Right ascension	Declination
Mercury	6 in.	241 9937.2–243 9654.3 (1913–1967)	1756	1695
	9	242 1867.2–243 1174.2 (1918–1944)	550	532
			2306	2227
Venus	6	242 0391.3–243 9679.3 (1914–1967)	2761	2582
	9	242 2113.3–243 1129.1 (1919–1944)	451	436
			3212	3018
Mars	6	242 4793.8–243 9658.5 (1926–1967)	549	528
	9	242 0105.8–243 1164.5 (1913–1944)	122	120
			671	648
Jupiter	6	242 4311.8–243 9548.6 (1965–1967)	656	624
	9	242 0330.8–243 1165.6 (1914–1944)	260	257
			916	881
Saturn	6	242 4607.8–243 9433.6 (1926–1966)	660	622
	9	242 0085.8–243 1122.6 (1914–1944)	280	280
			940	902
Uranus	6	243 4380.8–243 9595.6 (1925–1967)	639	628
	9	242 0321.8–243 1061.7 (1914–1943)	247	245
			886	873
Neptune	6	242 4531.8–243 9662.6 1925–1967)	618	606
	9	242 0129.8–243 1214.6 (1913–1944)	285	283
			903	889
Sun	6	241 9174.2–243 9682.2 (1911–1967)	5973	5695
	9	242 1867.2–243 1444.2 (1918–1944)	1696	1668
			7669	7363

The current ephemeris can predict the position of Venus to better than 20 μs in range. It has been found that the inclusion of Arecibo Ionospheric Observatory (AIO) data degrades this ephemeris. A systematic bias of approximately 30 μs appears in the residuals. Consequently, most AIO data have been removed from the data set pending re-examination of these data which is currently under way at AIO. The data set used in this development ephemeris is given in Table 4. This radar datum is also placed in a uniform format on punched cards (Ref. 17).

The first use of spacecraft data in ephemeris development is under way with the 60-year ephemerides. A total of 214 planetary range points covering the period June 21 to November 12, 1967 from the R&D planetary ranging system on *Mariner* V were used. These points are of 0.1 μs accuracy. Through the perturbations by Venus on the orbit of *Mariner* V during the encounter phase, the center of gravity of Venus can be determined at the time of encounter by *Mariner* V to 100 m in geocentric range and 5 m/day in geocentric range rate[2].

C. Ephemeris Computations

In the spring of 1968, the first simultaneous integration of all the planets was made at JPL. The initial conditions were close to those found in DE 19. These DE 19 initial conditions resulted from individual numerical integrations of all the planets using the relativistic differential equations fit to either the source theories from the USNO, or the Newcomb theories as programmed by N. Block in 1963. The initial conditions of Venus and the earth-moon barycenter differ from DE 19. These improved initial conditions are from DE 26.[3] These

[2]This assumes that the speed of light is given exactly by the IAU value of 299792.5 km/s.

[3]Lawson, C. L., "Announcement of JPL Development Ephemeris No. 26," Internal Document, Jet Propulsion Laboratory, Pasadena, Calif., June 7, 1967.

improved Venus and Earth-moon ephemerides resulted from comparison of the theories with optical observations from the 6-in. transit circle of the USNO between 1950 and 1965 and planetary radar from JPL, MIT, and AIO between 1961 and early 1967. A set of masses unlike those used in DE 19 or DE 69 were used (Ref. 14). The epoch conditions at JD 244 0400.5 were altered to reflect this change in planetary masses by constraining the osculating mean motions while adjusting the values for the semi-major axis. The expression

$$n^2a^3 = k^2(1+m+\delta m)$$

was used. A forward integration was made to the chosen "standard epoch" 2440800.5. At this point, the integrated epoch conditions for 1970 were used to begin a 20-year backward integration.

The initial comparison with the combined set of planetary range data of AIO, the Millstone Hill and Haystack sites of MIT, and JPL's, Venus site showed variations which were quite large (see Figs. 2, 3, and 4) as follows:

(1) +4000 to −2000 μs for Mercury.

(2) +1500 to approximately 0 μs for Venus with a positive offset.

(3) +3000 to −1000 μs for Mars.

These radar residuals along with a set of USNO 6-Inch Transit Circle Observations over the period 1950–1967 were used to correct the orbital elements of all the planets except Pluto, along with the radii and the astronomical unit.

A 56-parameter solution was made using these data. A rank 52 solution of an eigenvalue–eigenvector analysis was applied to the original osculating elements and a new integration performed[4]. The magnitudes of the radar range residuals were reduced by two orders of magnitude.

This first gravitationally consistent ephemeris computed at JPL was used from the Spring of 1968 until February 1969. At the completion of this initial effort, it was known that the outer planets were improved over the currently available ephemerides, but also that there was a need to fit over a much longer arc in order to obtain definitive ephemerides. Further, a longer arc of optical observations was needed to better determine the orientation of the ecliptic and the mean longitude of the earth-moon barycenter. Consequently, a 60-year numerical integration of the motion of the planets was made.

Table 4. Radar range observations

Data source	Period	Number of observations
Mercury		
AIO	243 8493.2–243 9363.2 (1964–1966)	119
Haystack (MIT)	243 9425.3–244 0064.2 (1966–1968)	88
	Summary 1964–1968	207
Venus		
Haystack (MIT)	243 9161.3–244 0063.2 (1967–1968)	63
JPL (Venus DSS)	243 8541.2–243 9707.6 (1964–1967)	284
Millstone Hill (MIT)	243 8447.0–243 9725.2 (1964–1967)	101
	Summary 1964–1968	448
Mars		
AIO	243 8719.0–243 8915.0 (1964–1965)	39
Haystack (MIT)	243 9587.7–243 9643.5 (1967)	10
	Summary 1964–1967	49

After a coordinate transformation to place the epoch conditions originally on the Schwarzschild metric into an isotropic form, a 60-year ephemeris was integrated. The interval of integration was from 1970 to 1910, and was designated DE 61.

A simultaneous solution of 63 parameters of the solar system was obtained reflecting the comparison of DE 61 with all the data discussed previously. The unknowns which are considered are the elements of the eight planets except Pluto, the right ascension and declination limb bias for Mercury and Venus, the radii of Mercury, Venus, and Mars, the six elements of *Mariner V*, the mass of Venus, and the astronomical unit. After some consideration, a rank 55 solution from the eigenvalue–eigenvector analysis was selected for re-integration.

D. Comparison with Theory

The Mercury radar range residuals are shown in Fig. 5. These residuals are the result of the solution just discussed. The mean error for the fit of data is 57 μs.

[4]Lawson, C. L., "Eigenvalue-Eigenvector Analysis for SSDPS," Internal Report, Jet Propulsion Laboratory, Pasadena, Calif., Jan. 17, 1968.

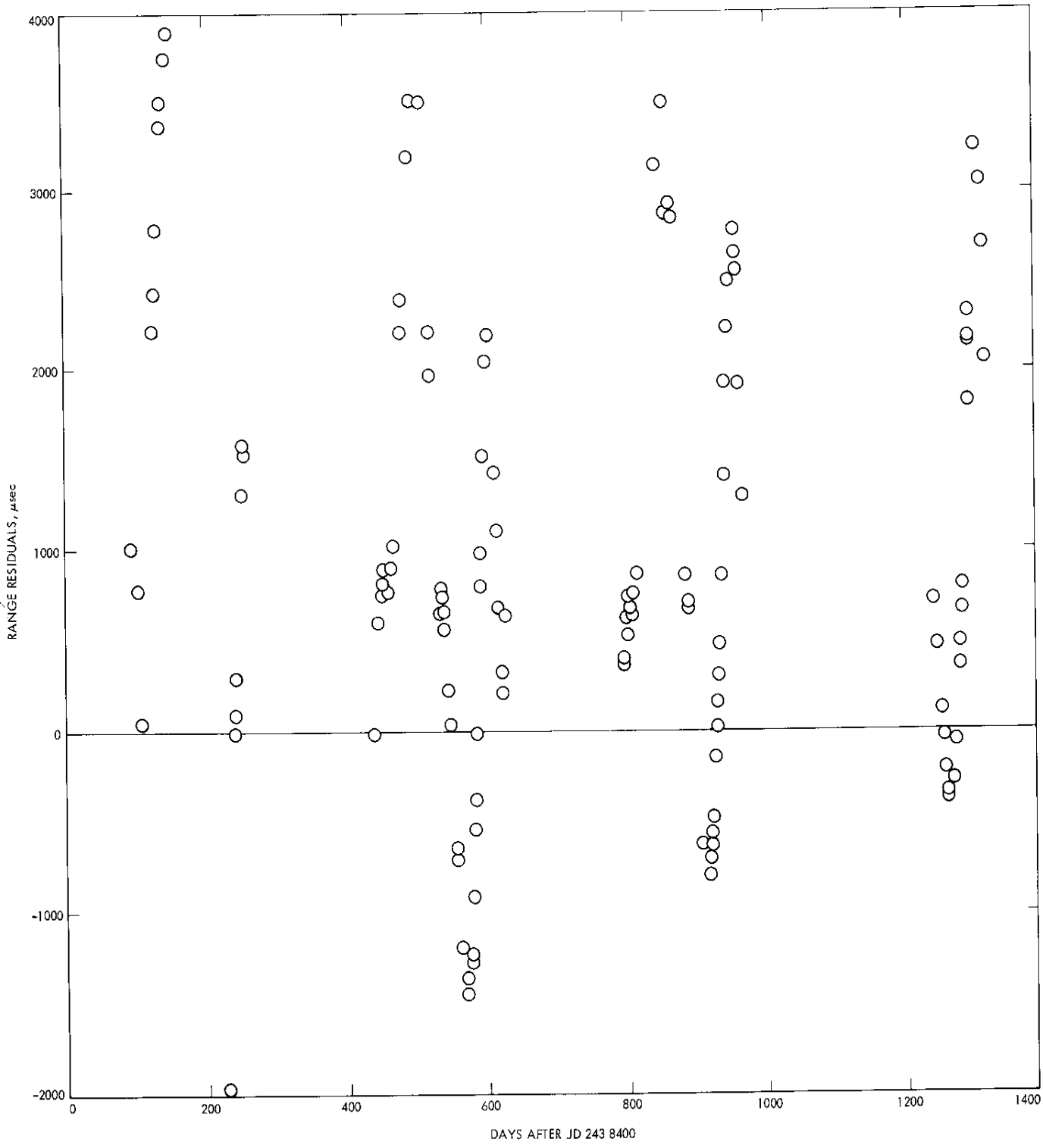

Fig. 2. Mercury radar range residuals with DE 35.

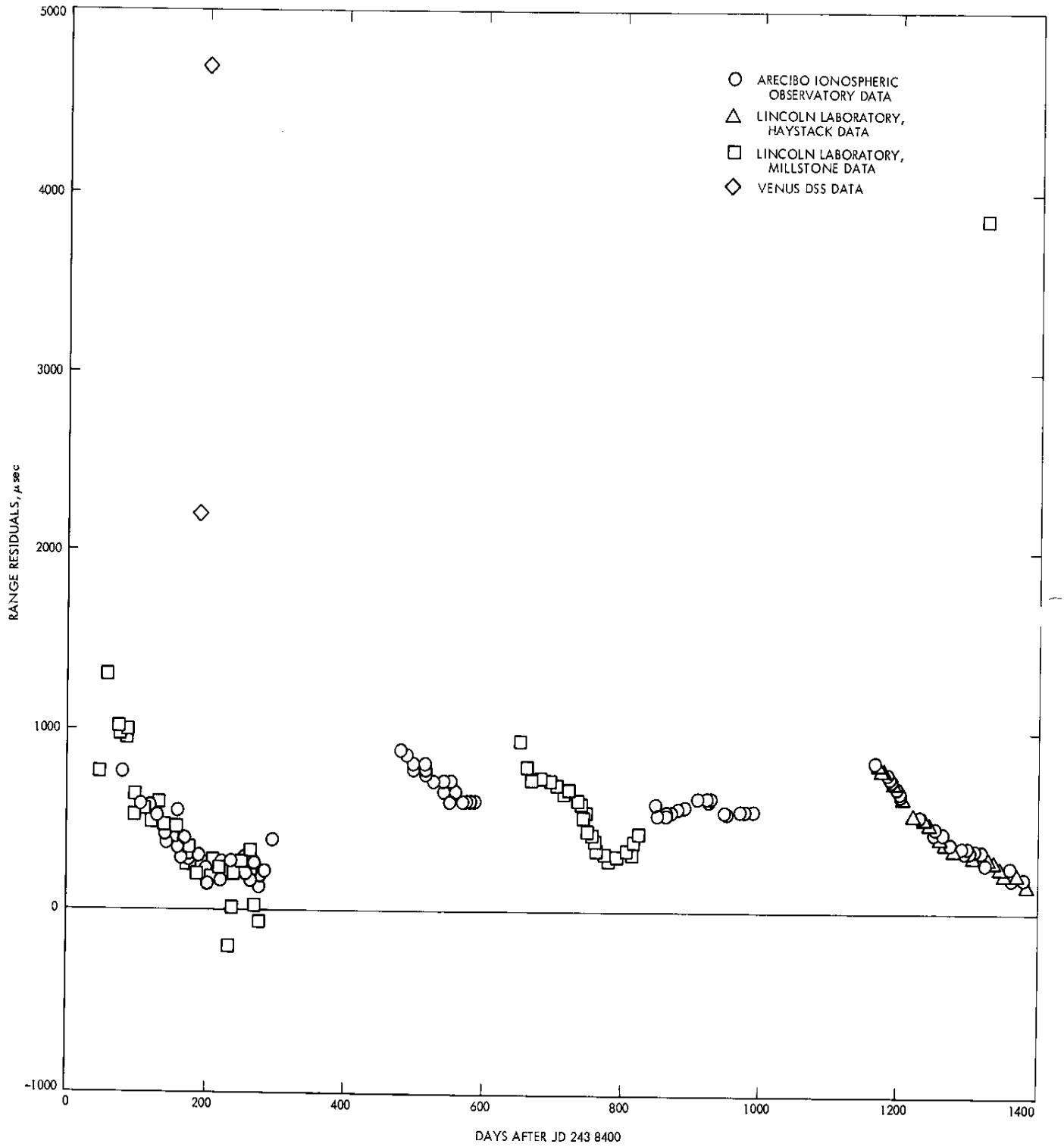

Fig. 3. Venus radar residuals with DE 35 (before fit).

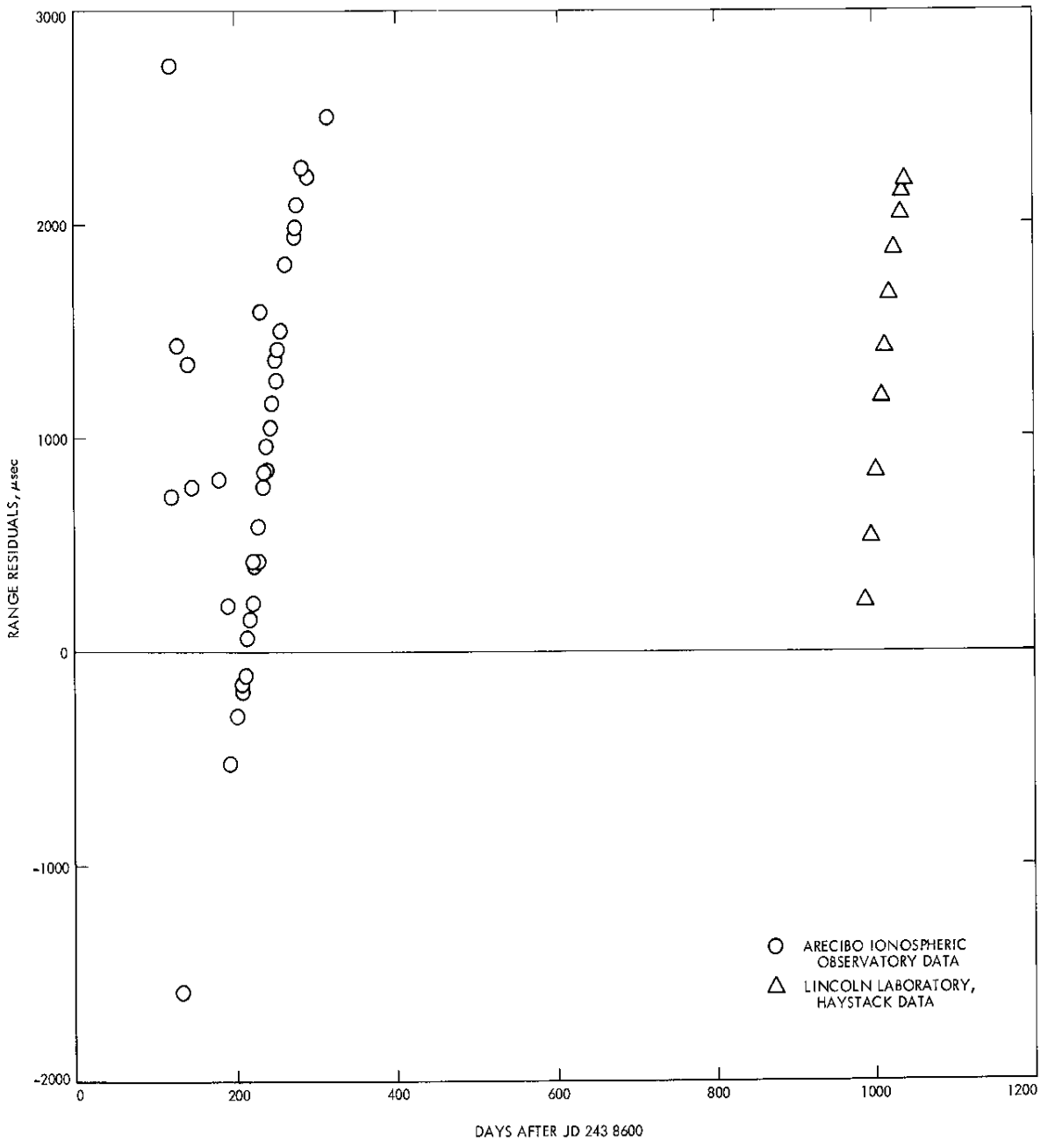

Fig. 4. Mars residuals compared with DE 35 (before fit).

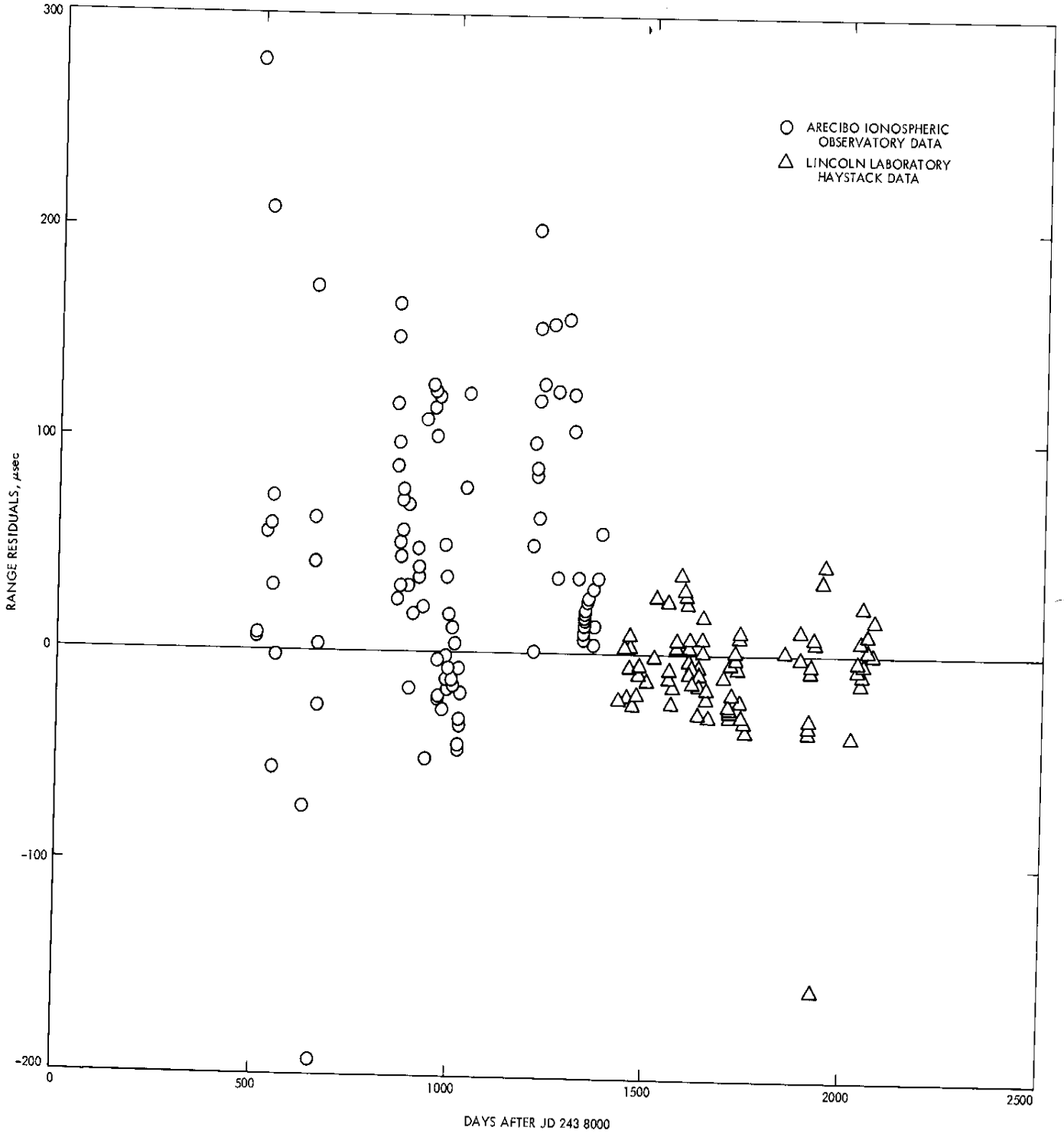

Fig. 5. Mercury radar range residuals—DE 69.

The increased radar detectability by the decreasing limits of radar residuals, as the data become more current, should also be noted. The standard deviations of the residuals on Mercury optical data are 1″.0 in right ascension and 0″.9 in declination.

Venus radar range data are from Millstone Hill, Haystack and JPL–Goldstone, the AIO data having been removed as a result of the previous discussions. The residuals based on DE 69 are shown in Fig. 6. The standard deviation for the fit of this data is 50 μsec.

The structure to be seen in the 1965/1966 Venus radar range residuals must be regarded as an anomaly in the modeling of the masses. If one considers the masses better known from spacecraft tracking, and therefore fixes the values, the reduction of degrees-of-freedom will cause the "feature" to appear in the Venus residuals. By altering the mass of Mercury, the feature and the overall sum of squared residuals are diminished.

The structure in the 1967 Venus-residuals has been removed. It was caused by mis-identification of the time base of the measurements.

Figure 7 shows the *Mariner V* residuals with respect to the 60-year integration. The precision of this new data type is seen by the scale which is in tenths of microseconds.

The optical residuals of Venus in right ascension have a standard deviation of 1″.2 and in declination 0″.9.

The 39 radar observations of Mars taken in 1964 at AIO, and the 10 high-precision-compressed points taken at Haystack in 1967, are shown in Fig. 8 compared to DE 69. The standard deviation, excluding the few early points, is 50 μs. The radar observations of Mars taken at JPL during the Spring and Summer of 1969 have not been included in DE 69.

The Sun and the planets, Jupiter, Saturn, Uranus, and Neptune, were fit to optical observations only. The residuals of the outer planets except Pluto are shown in Figs. 9 through 16. The periodic character of these residuals is indicative that further work is necessary on the planetary masses. Table 5 summarizes the statistics on the fit of the observations to DE 69.

In Appendix C are given all of the values to be used with DE 69. These reflect the solution just discussed.

Table 5. Statistics for fit of optical observations

Planet	Right ascension		Declination	
	Number of observations	Root mean square from mean	Number of observations	Root mean square from mean
1939–1967				
Mercury	913	.94	864	.93
Venus	1653	1.22	1504	.93
Mars	379	.52	360	.54
Jupiter	524	.45	498	.48
Saturn	509	.48	484	.53
Uranus	475	.33	465	.43
Neptune	519	.85	506	.60
Sun	3526	.76	3304	.60[a]
1910–1939				
Mercury	1394	1.04	1363	.85
Venus	1559	1.22	1514	.92
Mars	292	.72	288	.62
Jupiter	392	.54	383	.56
Saturn	431	.50[a]	416	.50[a]
Uranus	411	.48	408	.51
Neptune	384	.56	383	.46
Sun	4143	.80[a]	4059	.83

[a]These are estimated errors.

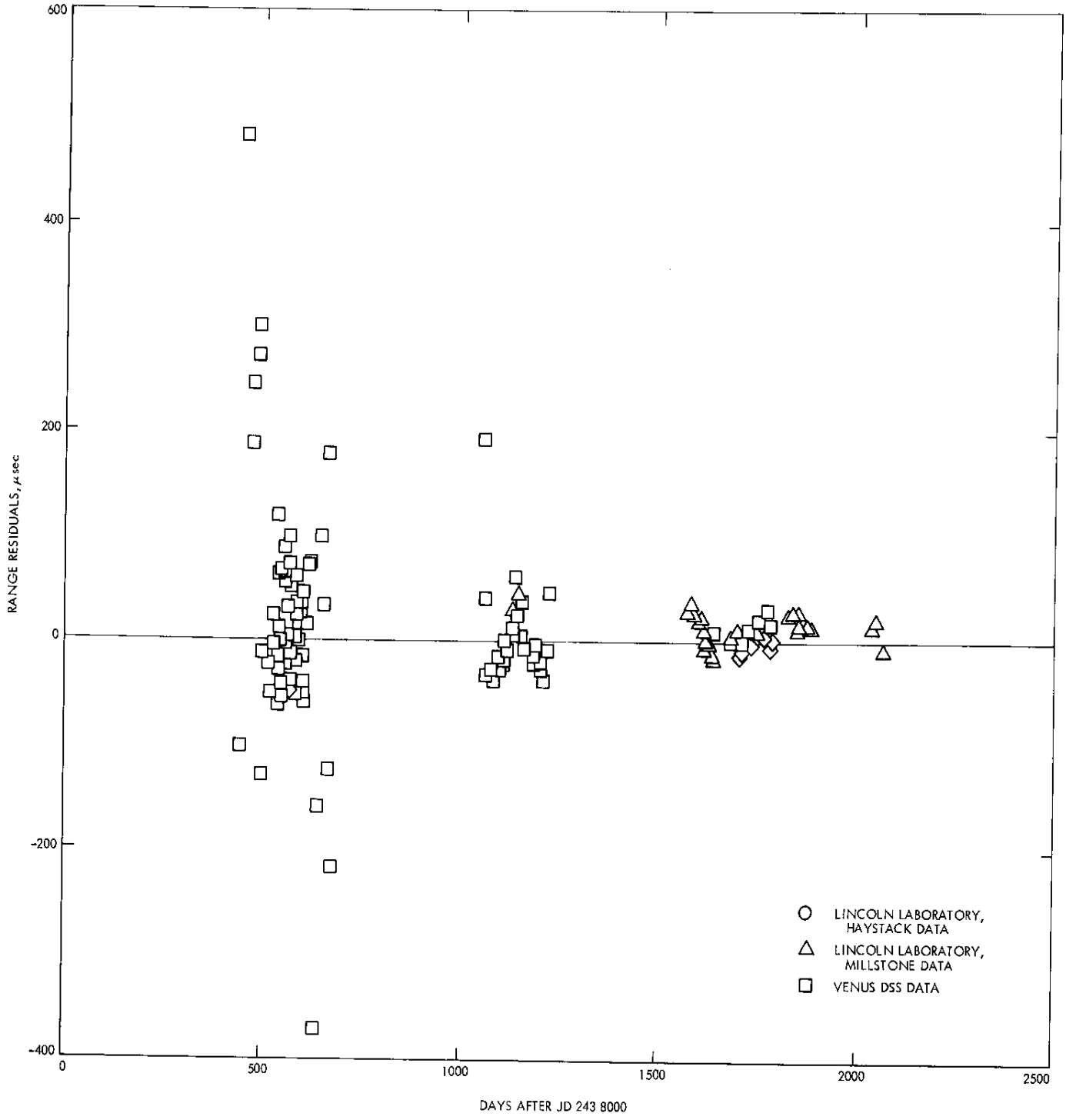

Fig. 6. Venus radar range residuals—DE 69.

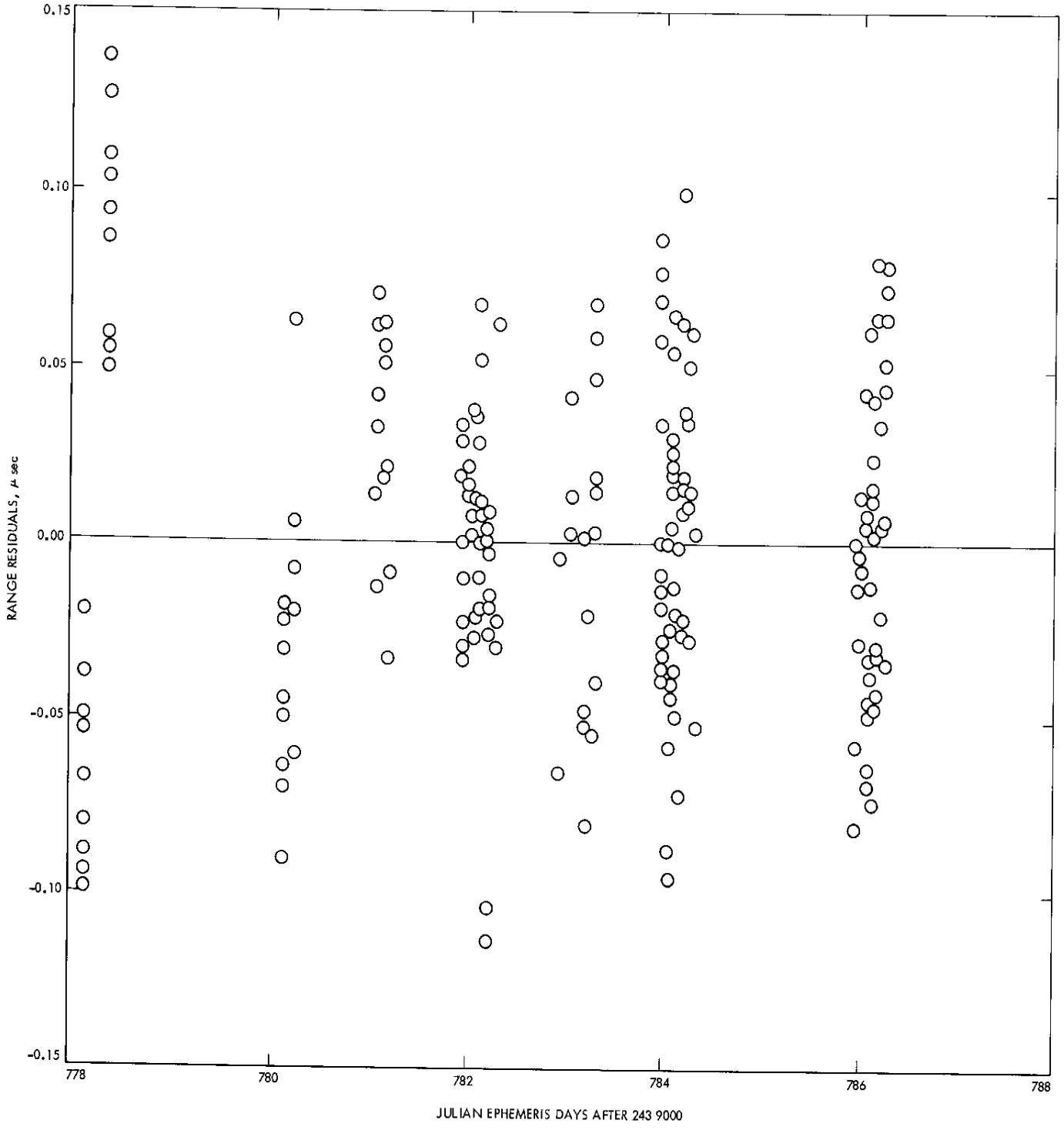

Fig. 7. *Mariner V* residuals.

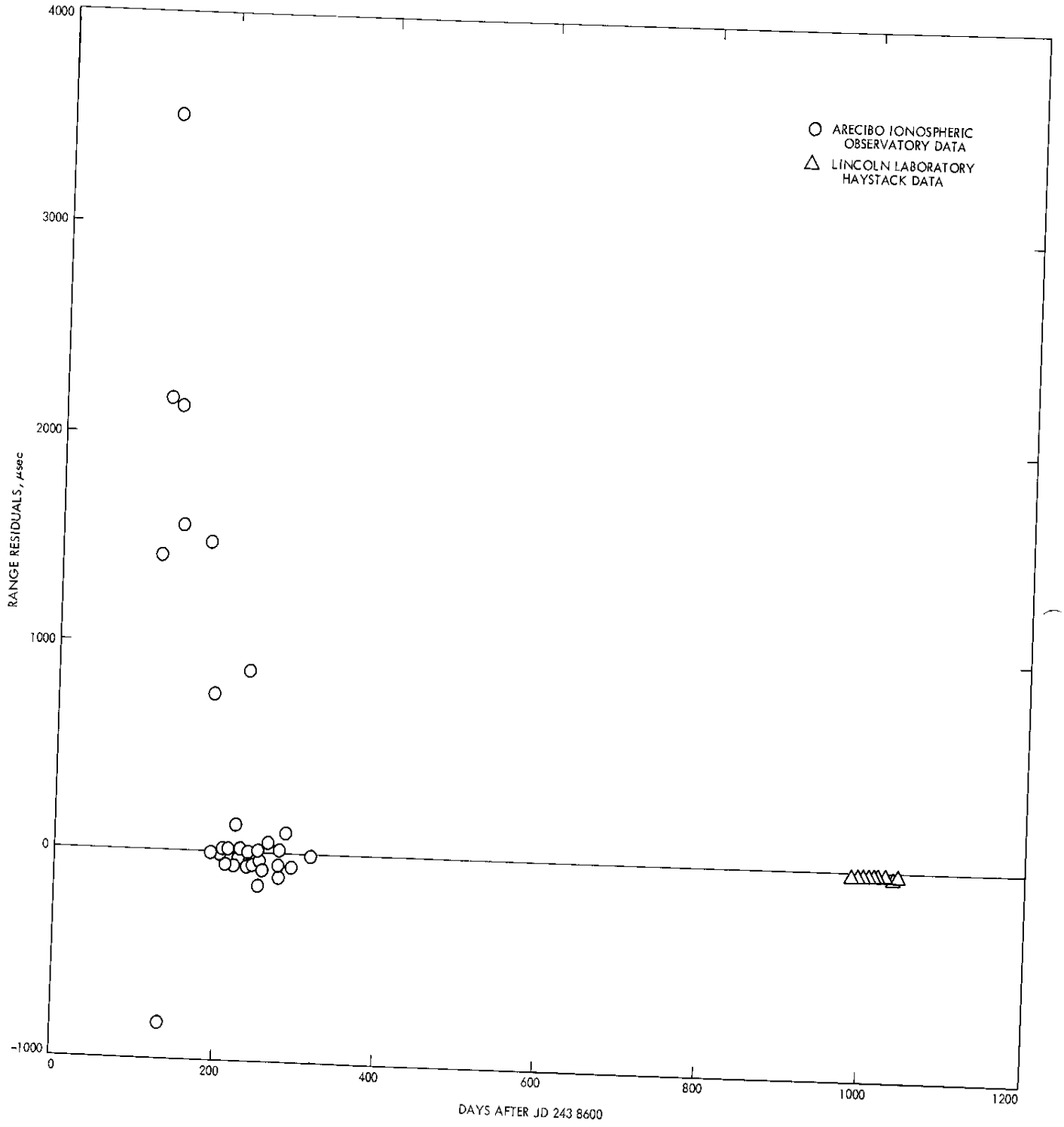

Fig. 8. Mars radar range residuals—DE 69.

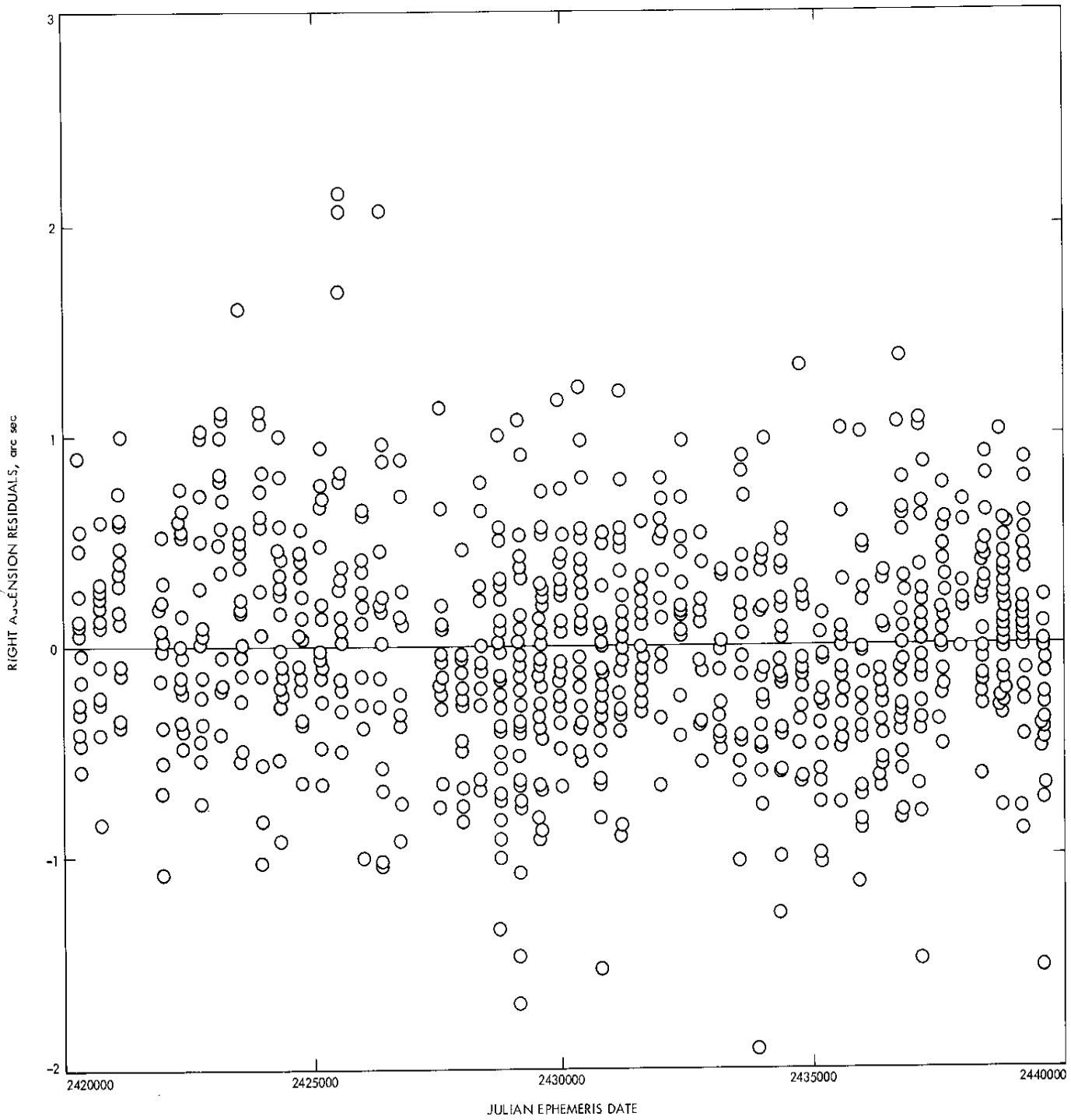

Fig. 9. Right ascension residuals—Jupiter.

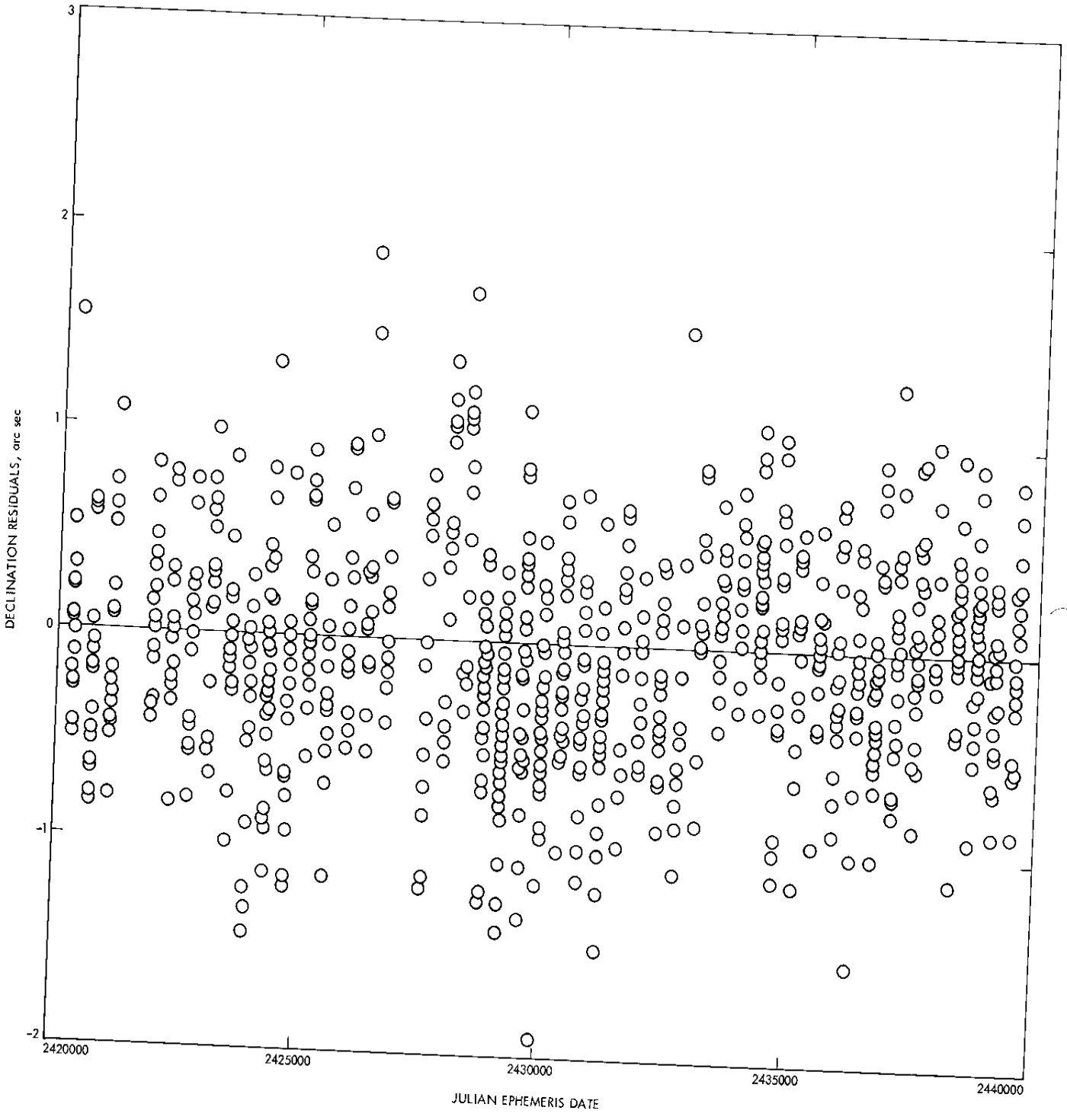

Fig. 10. Declination residuals—Jupiter.

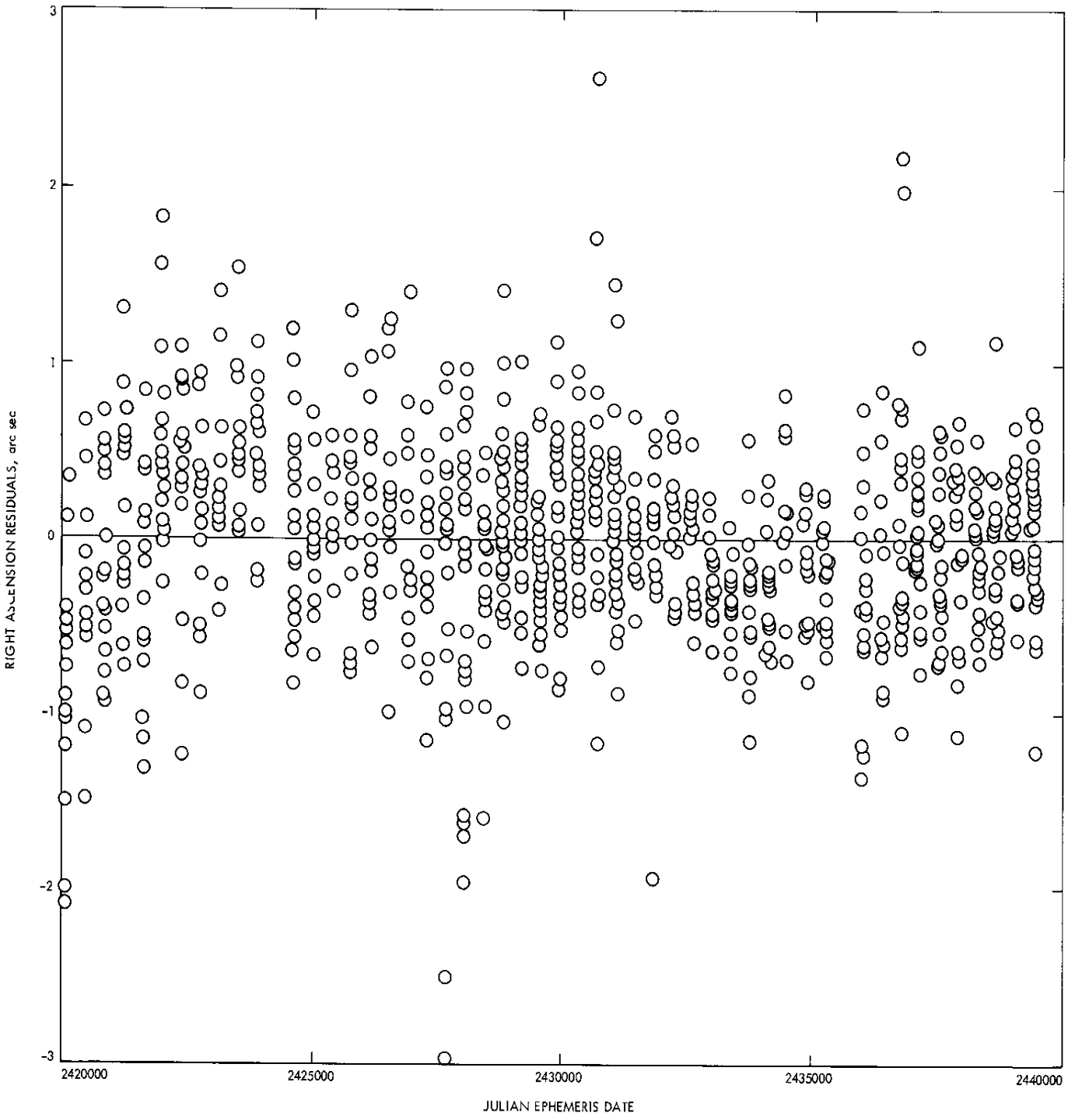

Fig. 11. Right ascension residuals—Saturn.

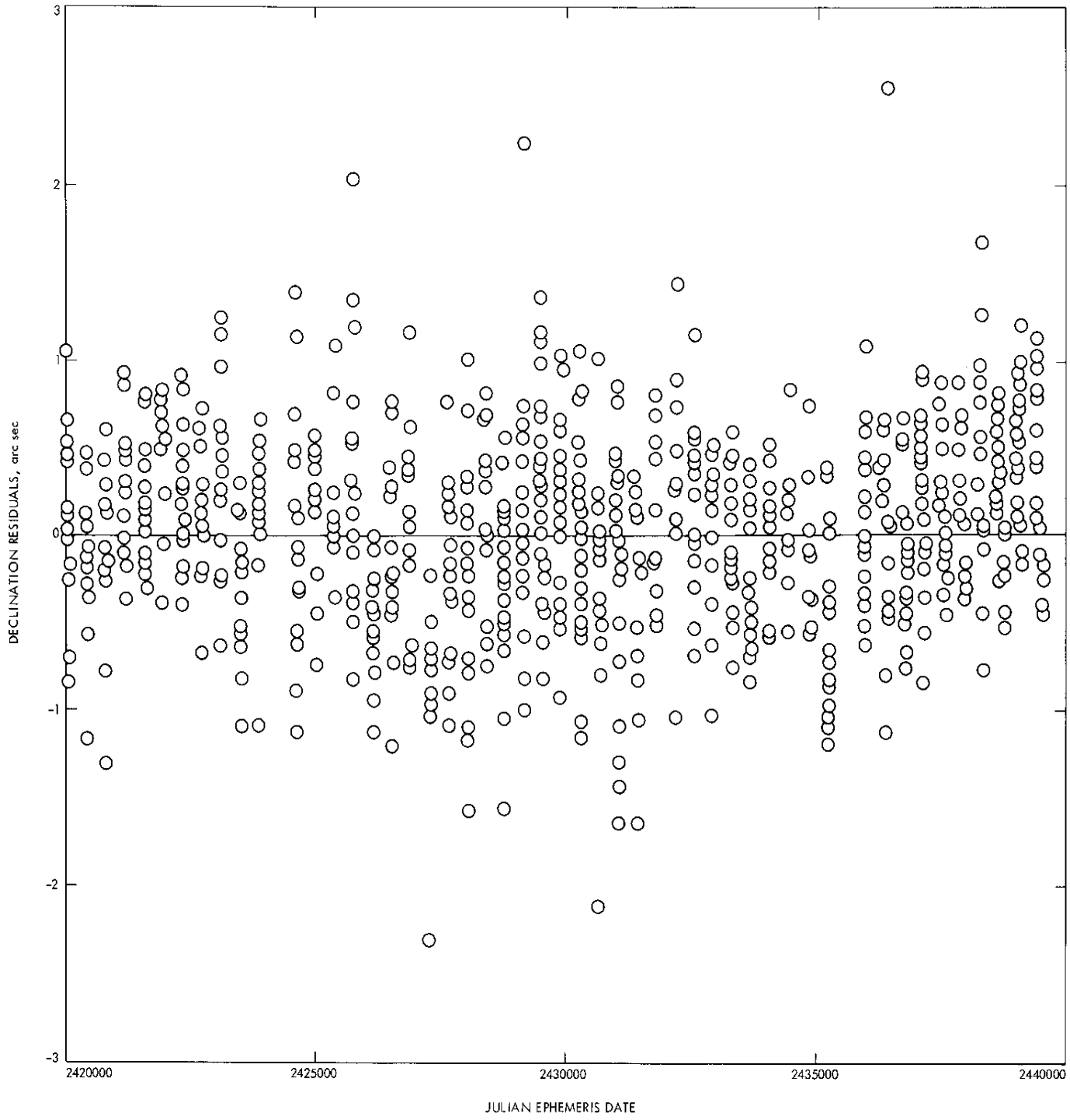

Fig. 12. Declination residuals—Saturn.

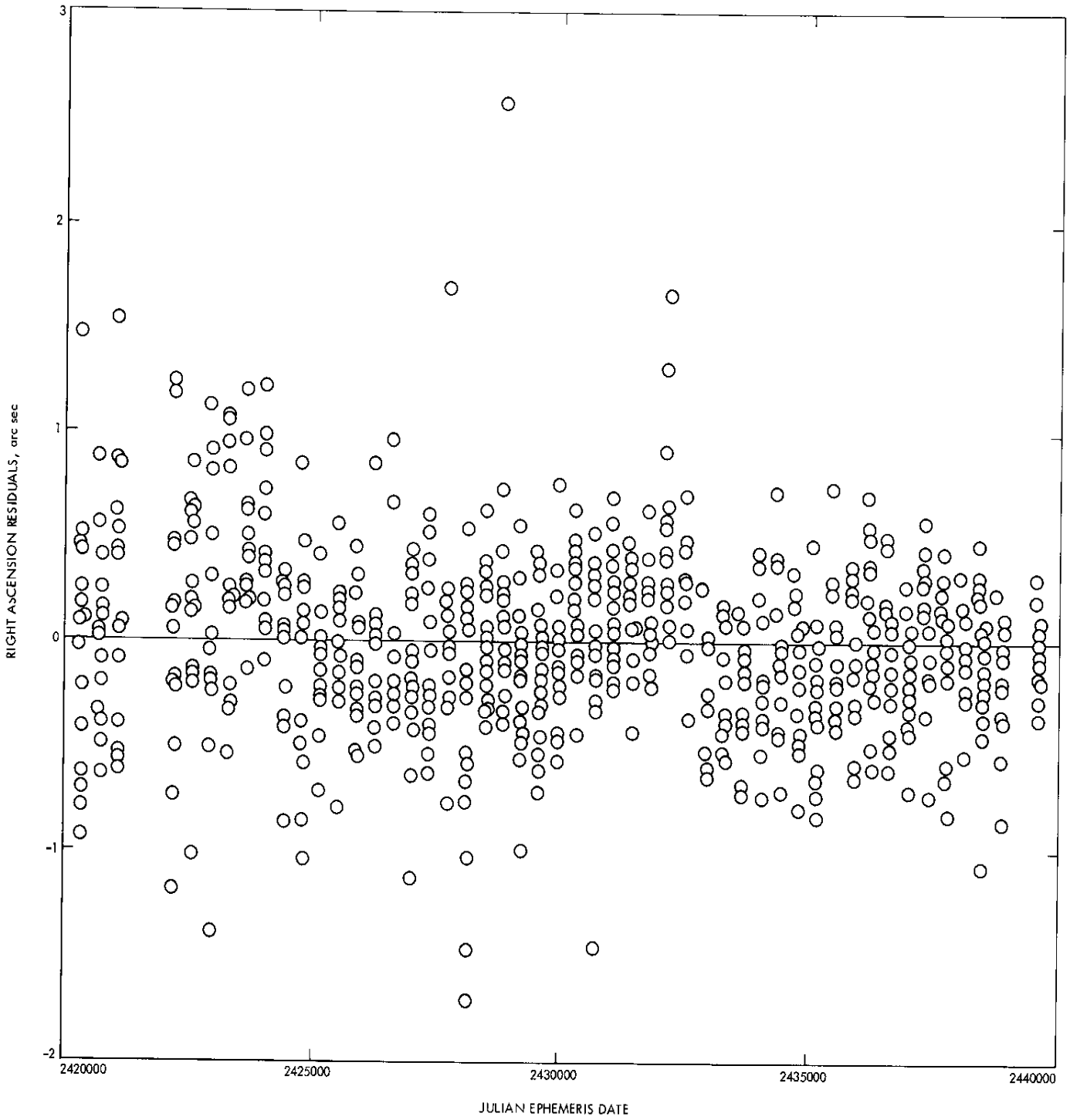

Fig. 13. Right ascension residuals—Uranus.

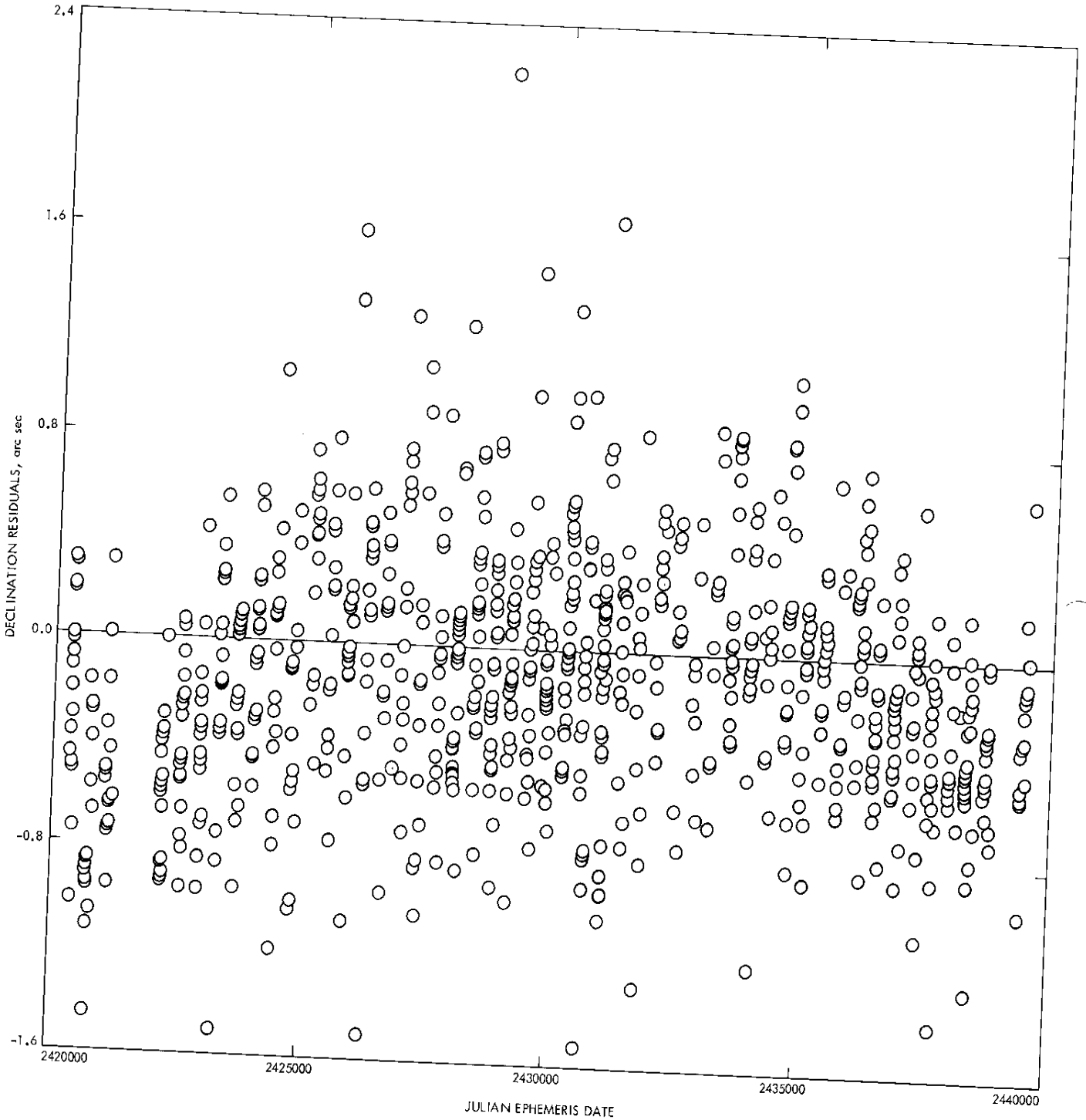

Fig. 14. Declination residuals—Uranus.

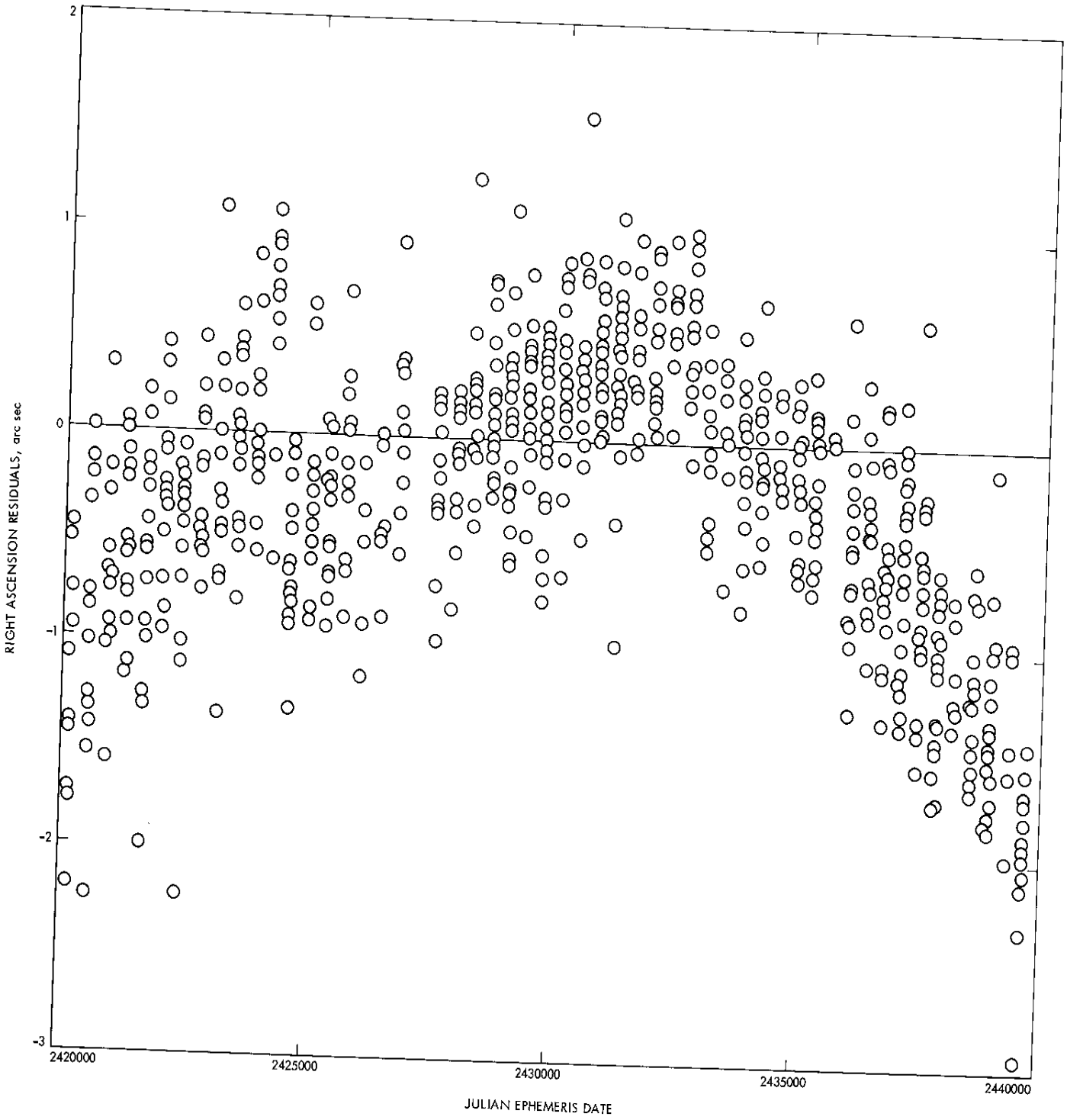

Fig. 15. Right ascension residuals—Neptune.

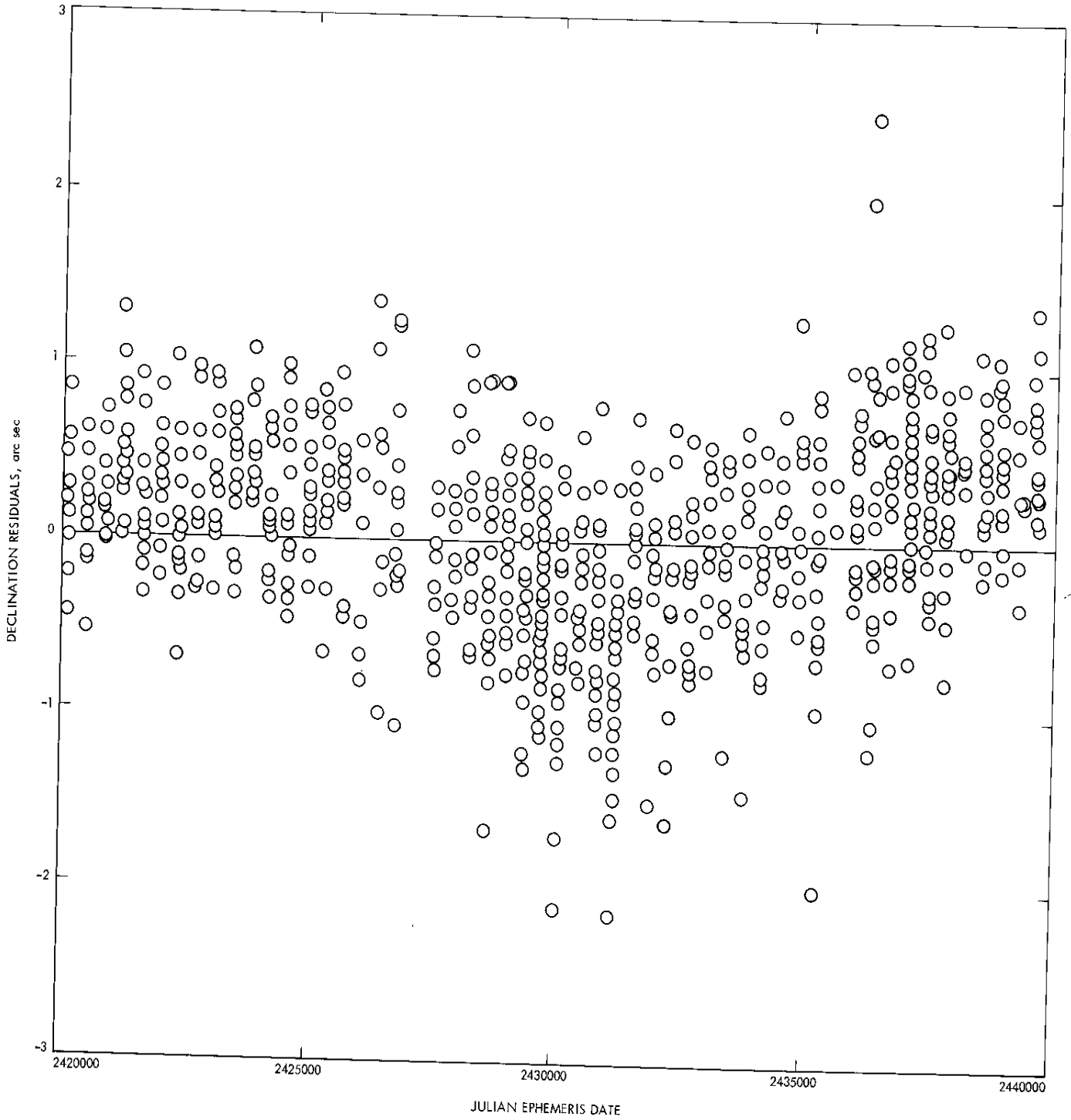

Fig. 16. Declination residuals—Neptune.

Appendix A

JPL Ephemeris Tape Format, Type 50

The JPL Ephemeris Tape Format, Type 50, contains two information records at the beginning of each tape followed by the data records. The record format may be described as follows:

(1) The first record of each tape contains 24 BCD words written in binary. These 24 words serve to describe the general nature of the information on the tape.

(2) The second record of each tape contains the following information in the order listed:

(a) Number of bodies on tapes = 10.

(b) A floating point 50, which denotes the Type 50 format.

(c) Initial Julian date for which data are provided.

(d) Final Julian date for which data are provided.

(e) Step size of the logical data record = 8.0 days.

(f) Ten pairs of numbers. The first number of the pair denotes the body in increasing order out from the Sun, with a zero used for lunar data. The second number of each pair is the step size of data provided for that body.

(3) The JPL Ephemeris Tapes contain data in buffered and overlapped 8-day logical records. The end points of the 8-day span are repeated as the first points of the succeeding 8-day record. This format allows ease of handling by the interpolation program.

The format for the JPL Ephemeris Tape records is listed in Table A-1. All data, with the exception of those for nutations, are double precision, so that the total record size is 1863 words. The step size for lunar data and nutations is ½ day. Mercury data are given in 2-day steps, and all other data in 4-day steps.

The Julian date is the epoch (Ephemeris Time, ET) of the start of the data record. Lunar positions and velocities are referred to the geocentric equatorial rectangular reference frame of the mean equator and equinox of 1950.0 = JD 243 3282.423. They are expressed in units called "earth radii" and "earth radii"/mean solar day. Planetary positions and velocities are referred to the heliocentric equatorial rectangular frames of 1950.0, and are expressed in units of AU and AU/mean solar day.

The conversion of position and velocity tabulations to laboratory units, such as kilometers and kilometers per

Table A-1. Ephemeris tape record format

Word in record	Data[a]
0	Julian Date
2	Mercury: $X, d^2X, d^4X, Y, d^2Y, d^4Y, Z, d^2Z, d^4Z$ Followed by four more position data points $\dot{X}, d^2\dot{X}, d^4\dot{X}, \dot{Y}, d^2\dot{Y}, d^4\dot{Y}, \dot{Z}, d^2\dot{Z}, d^4\dot{Z}$ Followed by four more velocity points
182	Venus: $X, d^2X, d^4X, Y, d^2Y, d^4Y, Z, d^2Z, d^4Z$ Followed by two more position data points $\dot{X}, d^2\dot{X}, d^4\dot{X}, \dot{Y}, d^2\dot{Y}, d^4\dot{Y}, \dot{Z}, d^2\dot{Z}, d^4\dot{Z}$ Followed by two more velocity data points
290	Earth–moon barycenter: Same as Venus
398	Mars: Same as Venus
506	Jupiter: Same as Venus
614	Saturn: Same as Venus
722	Uranus: Same as Venus
830	Neptune Same as Venus
938	Pluto: Same as Venus
1046	Moon: $X, d^2X, d^4X, Y, d^2Y, d^4Y, Z, d^2Z, d^4Z$ Followed by sixteen more position data points $\dot{X}, d^2\dot{X}, d^4\dot{X}, \dot{Y}, d^2\dot{Y}, d^4\dot{Y}, \dot{Z}, d^2\dot{Z}, d^4\dot{Z}$ Followed by sixteen more velocity data points
1658	Nutations: $\Delta\Psi, d^2\Delta\Psi, d^4\Delta\Psi, \Delta\varepsilon, d^2\Delta\varepsilon, d^4\Delta\varepsilon$ Followed by sixteen more nutation data points $\Delta\dot{\Psi}, d^2\Delta\dot{\Psi}, d^4\Delta\dot{\Psi}, \Delta\dot{\varepsilon}, d^2\Delta\dot{\varepsilon}, d^4\Delta\dot{\varepsilon}$ Followed by sixteen more nutation rate data points
1862	Check sum

[a]Where d^2 and d^4 are defined as in Eq. (A.1).

Table A-2. Maximum magnitude of *K*th difference of quantities tabulated

K	Mercury	Venus	Earth-moon barycenter	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Moon	$\Delta\psi$	$\Delta\varepsilon$
	AU	AU	AU	AU	AU	AU	AU	AU	AU	Earth radii	Rad	Rad
0	0.410E 00	0.725E 00	0.100E 01	0.165E 01	0.544E 01	0.951E 01	0.182E 02	0.280E 02	0.304E 02	0.636E 02	0.914E-04	0.481E 04
1	0.674E-01	0.811E-01	0.699E-01	0.582E-01	0.306E-01	0.235E-01	0.150E 01	0.125E-01	0.126E-01	0.745E 01	0.510E-06	0.202E-06
2	0.109E 01	0.911E 02	0.477E-02	0.245E-02	0.193E-03	0.538E-04	0.142E-04	0.497E 05	0.488E-05	0.916E 00	0.888E 07	0.384E-07
3	0.270E-02	0.103E-02	0.348E-03	0.983E 04	0.113E 05	0.156E 06	0.159E-07	0.704E-08	0.755E 08	0.124E 00	0.238E-07	0.106E-07
4	0.701E-03	0.117E 03	0.236E-04	0.560E-05	0.101E-07	0.221E 08	0.198E 08	0.199E-08	0.199E 08	0.188E 01	0.711E-08	0.304E 08
5	0.300E 03	0.138E-04	0.199E-05	0.325E-06	0.147E-08	0.142E-08	0.143E-08	0.143E 08	0.143E 08	0.359E-02	0.223E 08	0.992E-09
6	0.129E-03	0.166E 05	0.161E 06	0.306E 07	0.227E 08	0.227E 08	0.227E-08	0.227E-08	0.227E 08	0.857E-03	0.790E-09	0.371E-09
7	0.833E-04	0.225E-06	0.205E-07	0.663E-08	0.412E-08	0.412E-08	0.412E 08	0.412E-08	0.412E-08	0.262E 03	0.457E-09	0.188E-09
8	0.507E-04	0.340E-07	0.101E-07	0.803E 08	0.791E 08	0.791E-08	0.791E 08	0.791E 08	0.791E 08	0.936E 04	0.587E 09	0.260E 09
9	0.422E-04	0.869E 08	0.138E 07	0.142E 07	0.140E 07	0.140E 07	0.140E-07	0.140E 07	0.140E 07	0.425E 04	0.954E 09	0.484E 09
10	0.328E 04	0.533E 08	0.201E-07	0.275E-07	0.273E 07	0.273E 07	0.273E-07	0.273E 07	0.273E 07	0.284E 04	0.189E 08	0.966E-09
11	0.323E 04	0.692E-08	0.343E-07	0.498E 07	0.489E-07	0.489E-07	0.489E 07	0.489E 07	0.489E 07	0.487E-04	0.358E-08	0.183E 08
12	0.299E-04	0.122E 07	0.516E 07	0.964E 07	0.956E 07	0.956E 07	0.956E-07	0.956E-07	0.956E 07	0.895E-04	0.715E 08	0.360E 08
13	0.335E 04	0.181E 07	0.910E-07	0.177E-06	0.174E-06	0.174E 06	0.174E-06	0.174E 06	0.174E 06	0.174E 03	0.137E 07	0.695E 08
14	0.354E 04	0.337E-07	0.142E-06	0.343E 06	0.340E-06	0.340E 06	0.340E 06	0.340E 06	0.340E-06	0.335E 03	0.273E 07	0.136E-07
15	0.437E 04	0.534E 07	0.260E-06	0.635E 06	0.624E-06	0.624E-06	0.624E-06	0.624E 06	0.624E-06	0.658E 03	0.528E-07	0.268E-07
	AU/day	AU/day	AU/day	AU/day	AU/day	AU/day	AU/day	AU/day	AU/day	Earth radii/day	Rad/day	Rad/day
0	0.338E 01	0.203E-01	0.175E-01	0.145E 01	0.764E-02	0.588E 02	0.376E 02	0.313E-02	0.315E 02	0.149E 02	0.102E 05	0.407E 06
1	0.548E 02	0.228E 02	0.119E 02	0.612E 03	0.482E 04	0.134E-04	0.356E-05	0.124E 05	0.122E 05	0.183E 01	0.178E 06	0.776E 07
2	0.136E 02	0.258E 03	0.870E-04	0.246E 04	0.283E 06	0.391E-07	0.402E-08	0.182E 08	0.186E 08	0.247E 00	0.483E-07	0.215E-07
3	0.353E 03	0.293E 04	0.590E 05	0.140E 05	0.254E-08	0.589E 09	0.517E-09	0.519E 09	0.520E 09	0.377E-01	0.142E-07	0.618E-08
4	0.152E 03	0.344E 05	0.498E 06	0.814E-07	0.602E-09	0.604E-09	0.603E 09	0.603E 09	0.603E 09	0.717E 02	0.440E 08	0.201E 08
5	0.654E 04	0.416E-06	0.400E-07	0.784E-08	0.107E 08	0.107E-08	0.107E-08	0.107E 08	0.107E-08	0.172E 02	0.161E-08	0.743E 09
6	0.426E-04	0.564E 07	0.534E 08	0.251E 08	0.203E-08	0.203E 08	0.203E-08	0.203E 08	0.203E 08	0.527E 03	0.769E-09	0.377E-09
7	0.261E-04	0.857E 08	0.306E 08	0.361E 08	0.352E-08	0.352E 08	0.352E-08	0.352E 08	0.352E 08	0.188E 03	0.746E-09	0.395E 09
8	0.219E 04	0.210E 08	0.394E-08	0.689E-08	0.681E-08	0.681E 08	0.681E-08	0.681E 08	0.681E 08	0.833E 04	0.130E 08	0.693E 09
9	0.171E-04	0.159E 08	0.649E 08	0.123E-07	0.121E 07	0.121E-07	0.121E-07	0.121E 07	0.121E 07	0.476E 04	0.249E-08	0.128E 08
10	0.170E 04	0.204E 08	0.102E-07	0.237E 07	0.235E-07	0.235E 07	0.235E-07	0.235E 07	0.235E 07	0.506E-04	0.478E-08	0.243E 08
11	0.159E 04	0.352E-08	0.173E-07	0.431E-07	0.423E 07	0.423E-07	0.423E 07	0.423E-07	0.423E-07	0.879E 04	0.920E 08	0.467E 08
12	0.179E 04	0.539E 08	0.295E-07	0.835E-07	0.826E-07	0.826E-07	0.826E-07	0.826E 07	0.826E-07	0.164E 03	0.181E 07	0.922E 08
13	0.191E-04	0.983E 08	0.507E 07	0.153E-06	0.150E-06	0.150E 06	0.150E-06	0.150E-06	0.150E-06	0.302E 03	0.349E-07	0.178E-07
14	0.237E 04	0.163E 07	0.925E-07	0.298E 06	0.294E-06	0.294E-06	0.294E 06	0.294E-06	0.294E 06	0.575E-03	0.685E-07	0.350E 07
15	0.280E 04	0.297E-07	0.161E-06	0.550E 06	0.541E 06	0.541E-06	0.541E-06	0.541E 06	0.541E-06	0.109E-02	0.133E-06	0.681E 07

*Step size is 0.5 day for moon and nutations, 2 days for Mercury, and 4 days for others.

second, requires scaling by the conversion factors kilometers/AU and kilometers/"earth radius." Conversion of planetary data from a heliocentric to a geocentric frame of reference requires specification of the earth-moon mass ratio μ to locate the earth-moon barycenter in the geocentric frame. Finally, if data are required for a particular epoch in Universal Time (UT), the time correction Δt_q = ET − UT must be specified.

Interpolation

The JPL ephemeris (format type 50) contains modified second and fourth differences computed as follows:

$$d_j^2 = \delta_j^2 + a_{26}\,\delta_j^6 + a_{28}\,\delta_j^8$$
$$d_j^4 = \delta_j^4 + a_{46}\,\delta_j^6 + a_{48}\,\delta_j^8 \qquad \text{(A.1)}$$

where

$$a_{26} = -0.013120 \qquad a_{28} = 0.004299$$
$$a_{46} = -0.278269 \qquad a_{48} = 0.068489$$

These modified differences are intended to facilitate the use of Everett's fifth-order interpolation formula which may be written as

$$y(t_j + sh) \cong P(s) \equiv y_j F_0(1-s) + d_j^2 F_2(1-s) + d_j^4 F_4(1-s) + y_{j+1} F_0(s) + d_{j+1}^2 F_2(s) + d_{j+1}^4 F_4(s) \qquad \text{(A.2)}$$

where

$$F_0(s) = s$$
$$F_2(s) = [(s-1)(s)(s+1)]/6$$
$$F_4(s) = [(s-2)(s-1)(s)(s+1)(s+2)]/120$$

Equation (A.2) is to be used only with $0 \le s \le 1$, in which case, the truncation error can be shown to be bounded as follows:

$$|y - P| \le \sum_{k=6}^{9} b_k M_k + b_{10}\,\hat{M}_{10} \qquad \text{(A.3)}$$

where

$$M_k = \max |\delta^k|$$
$$\hat{M}_k = h^k \max \left|\frac{d^k y}{dt^k}\right|$$
$$b_6 = 8.35 \times 10^{-7}$$
$$b_7 = 8.99 \times 10^{-6}$$
$$b_8 = 3.05 \times 10^{-7}$$
$$b_9 = 3.48 \times 10^{-6}$$
$$b_{10} = 2.40 \times 10^{-4}$$

The quantities of M_k are given in Table A-2 for $k = 0, 1, \cdots, 15$ as computed from DE19B. The quantity $\hat{M}_{10}$ has not been computed directly because of the difficulty of computing $d^{10}y/dt^{10}$. However, since $h^{10}(d^{10}y/dt^{10}) = \delta^{10} - (5/12)\,\delta^{12} + \cdots$, (Ref. 19), we will use M_{10} as an approximation to $\hat{M}_{10}$.

With $\hat{M}_{10}$ replaced by M_{10}, Eq. (A.3) has been evaluated, using the data given in Table A-2, and the resulting interpolation error bounds are listed in Table A-3.

Table A-3. Bound for truncation error when using fifth-order Everett interpolation formula[a]

Body	Position	Velocity
Mercury	8890.00 AU	4420.00 AU/day
Venus	4.73 AU	0.62 AU/day
Earth-moon barycenter	5.19 AU	2.50 AU/day
Mars	6.74 AU	5.77 AU/day
Jupiter	6.64 AU	5.72 AU/day
Saturn	6.64 AU	5.72 AU/day
Uranus	6.64 AU	5.72 AU/day
Neptune	6.64 AU	5.72 AU/day
Pluto	6.64 AU	5.72 AU/day
Moon	10100.00 earth radii	14500.00 earth radii/day
$\Delta\psi$	0.46 rad	1.16 rad/day
$\Delta\varepsilon$	0.23 rad	0.58 rad/day

[a]All entries have been multiplied by 10^{12}; step size is 2 days for Mercury, 0.5 day for moon, $\Delta\psi$, and $\Delta\varepsilon$, and 4 days for all others.

Appendix B

Description of FORTRAN IV Ephemeris Reading Subroutine READE

It should be noted that the format of the ephemeris tapes in DE 69 is exactly the format of DE 19; hence, any subroutine used to read DE 19 may be used without modification to read DE 69. The following subroutine system has been submitted to COSMIC for secondary distribution.

I. Identification

(1) READE read, interpolate, and translate JPL Ephemeris.

(2) Program language: FORTRAN IV.

(3) Machine: IBM 7094, UNIVAC 1108.

(4) C. L. Lawson (JPL) and J. E. Ekelund (Planning Research Corp.), June 13, 1966.

II. Purpose

This subroutine is to be used to obtain ephemeris data from a JPL Ephemeris Tape. The data will be interpolated to the Julian Ephemeris Date given by JED + TSEC/86400. The position and velocity vectors may be translated to provide the position and velocity vectors of any requested set of bodies relative to any requested central body.

III. Usage Part 1 (Basic Features)

A JPL Ephemeris Tape must be mounted on FORTRAN Unit 12. The tape format must be Type 50 (see Appendix A).

The user's program must contain the following statements:

```
COMMON/CETBL1/AU, RE, TPD,EMRAT

COMMON/CETBL2/ICW,ICENT,IREQ (13)

COMMON/CETBL4/TABOUT (6, 12), NUT (4)

DOUBLE PRECISION AU, RE, TPD, EMRAT,
TABOUT, NUT, JED,TSEC

CALL READE (JED, TSEC, IERR)

IF (IERR .NE. 0) GO TO [error procedure]
```

The parameters in CETBL1 and CETBL2 and the parameters JED and TSEC must be set by the user before calling READE. READE will place its output in CETBL4 and will set the error flag IERR and may modify the flag ICW. The parameters are as follows:

Parameter	Description
AU, RE, TPD	These three parameters determine units of the output quantities. The planetary ephemerides are recorded in AU and in AU per ephemeris day. The lunar ephemeris is recorded in "earth radii" and in "earth radii" per ephemeris day. The nutation parameters are recorded in radians and radians per ephemeris day. The user must set: AU = number of output linear units in an AU RE = number of output linear units in an "earth radius" TPD = number of output time units in an ephemeris day.
EMRAT	Ratio of the mass of the Earth to the mass of the moon. This ratio is used to locate the relative position of the Earth-moon barycenter.
ICW	Flag indicating the status of arrays into which READE reads ephemeris tape records. The user must set ICW = 1 before the first CALL to READE and should generally leave ICW alone thereafter.

Parameter	Description
ICENT	Index of body to be used as central body relative to which coordinates of requested bodies will be given. The indexes are: 1 Mercury 5 Jupiter 9 Pluto 2 Venus 6 Saturn 10 Sun 3 Earth 7 Uranus 11 Moon 4 Mars 8 Neptune (Note that earth-moon barycenter is not a permissible center.)
[IREQ (J), J = 1,13]	IREQ (J) specifies the type of output desired for body J. IREQ (J) = 0 means no output = 1 means position only = 2 means position and velocity The body numbers are assigned as given above for ICENT with the addition of 12 for earth-moon barycenter and 13 for nutation parameters.
{[TABOUT(I,J), I = 1,6], J = 1,12}	Output coordinates. The first index runs through $x,y,z,\dot{x},\dot{y}$ and $\dot{z}$ in that order. The second index is the body number.
[NUT (I), I = 1,4]	Output values of the nutation parameters: NUT (1) = $\Delta\psi$ = Δ longitude NUT (2) = $\Delta\varepsilon$ = Δ obliquity NUT (3) = time derivative of $\Delta\psi$ NUT (4) = time derivative of $\Delta\varepsilon$.
JED, TSEC	Taken together these two parameters specify the epoch of ephemeris time at which ephemeris data is desired. The epoch is ET = JED + (TSEC/86400.D0). Any combination of values of JED and TSEC such that ET falls within the time span of the ephemeris tape is permissible. Highest resolution in interpolation will be obtained if JED is an exact binary number representing a Julian date close to the epoch of interest ET.

Parameter	Description
IERR	Error flag set by READE: 0 No error 1 (JED + TSEC/86400.D0) is smaller than first date on ephemeris tape 2 (JED + TSEC/86400.D0) is greater than last date on ephemeris tape 3 IREQ (J) is not 0,1, or 2 for some J 4 ICENT is not 1,2, ···, or 11 5 ICW is not 1, 2, or 3.

IV. Usage Part 2 (Other Features)

Besides the COMMON blocks mentioned, there are other COMMON blocks used by READE and GETTAP which may be of interest to the user:

```
COMMON/CETBL3/TAB3(0829), NUTAT(204),
CKSUM

COMMON/CETBL5/BIVECT(6,13)

COMMON/CETBL9/JD1, TDAY, JDIF, IERR1

COMMON/REC1/REC1 (24)

COMMON/REC2/TBODY, TYPE, AJD, BJD, STEP,
DUM20(20)

DOUBLE PRECISION TAB3, BIVECT, JD1, TDAY,
JDIF

REAL          NUTAT

INTEGER       CKSUM
```

The standard 1863 word data record from an ephemeris tape is read by GETTAP into TAB3, NUTAT, and CKSUM.

BIVECT is working space for READE. On exit from READE, BIVECT contains interpolated and scaled, but not translated, ephemeris coordinates. The body numbering is not exactly the same as in TABOUT.

CETBL9 is used for communication between READE and GETTAP.

GETTAP reads the first two identification records of an ephemeris tape into REC1 and REC2, respectively. REC1 is a 144-character BCD identification text. REC2 contains 25 single precision floating point numbers. Of these two records, only the three items AJD, BJD, and STEP are used by READE and GETTAP.

The flag ICW has three permissible values:

Value	Description
1	Means GETTAP must rewind the ephemeris tape and read records 1 and 2 and the first data record before beginning to search for the requested epoch.
2	Means GETTAP can immediately begin to search for the requested epoch since records 1 and 2 have already been read into REC1 and
2 (contd)	REC2 and the last data record read from tape is in CETBL3. GETTAP always sets ICW = 2 after reading a data record.
3	Means REC1 and REC2 have been preserved, but CETBL3 has not (possibly due to OVERLAY) and, thus, GETTAP must read one data record before beginning to search for the requested epoch.

V. Subroutines Used

The FORTRAN IV SUBROUTINE, GETTAP, is used to position the tape and read the correct data record into CETBL3. All I/O is done via standard FORTRAN IV statements.

Appendix C

DE 69 Constants

The following table lists constants for DE 69.

Velocity of light	299 752.5 km/s
Radii	
Moon	1738 km
Mercury	2441
Venus	6053
Mars	3376
Jupiter	71350
Saturn	60400
Uranus	23800
Neptune	22300
Pluto	7200
Sun	696 000

Appendix D

Nominal Value Input Cards

Table D-1 presents the nominal value input cards.

Table D-1. Nominal value input cards

Body	AU			AU/Day		
	X	Y	Z	$\dot{X}$	$\dot{Y}$	$\dot{Z}$
Moon	1.957201476459373D-03	−1.601313108959806D-03	9.684816460558743D-04	−4.584079593648413D-04	−2.786992359772400D-04	−1.706976322327463D-04
Earth–Moon barycenter	6.388223239692001D-01	−7.234668700684017D-01	−3.137194324577663D-01	1.308702468621249D-02	9.880583281228748D-03	4.284450687694985D-03
Mercury	−3.472828490907576D-01	−2.538198004029557D-01	−1.002522097205557D-01	1.164349789102359D-02	−1.796892566378662D-02	−1.081910535895070D-02
Venus	−2.729262059304316D-01	−6.191876072511641D-01	−2.617880857259560D-01	1.860072423467568D-02	−6.590520902680456D-03	−4.144660068370773D-03
Mars	−1.043273791584276D 00	1.149610170700971D 00	5.556918002442636D-01	−1.028576013130965D-02	−7.076373218558543D-03	−2.972113161620146D-03
Jupiter	−4.241144808148452D 00	−3.149104334834158D 00	−1.247301166271148D 00	4.626302582644397D-03	−5.059629126080921D-03	−2.283657425358879D-03
Saturn	6.459617061053484D 00	6.101128619727081D 00	2.243375059274648D 00	−4.252230932057857D-03	3.559268583257949D-03	1.655567450141698D-03
Uranus	−1.814313887576205D 01	−2.460514498777027D 00	−8.216992903049754D-01	5.261848130241593D-04	−3.735781938971764D-03	−1.644315967838234D-03
Neptune	−1.530781100256404D 01	−2.435404000527554D 01	−9.591123470954914D 00	2.693366882765193D-03	−1.429427158965292D-03	−6.534123487881678D-04
Pluto	−3.031628535965546D 01	−1.792426075828660D 00	8.620253359544401D 00	3.986115845958216D-04	−3.146654477732543D-03	−1.114235223116397D-03

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Y M D H M = 71 12 07 100 29 1108 JPL EPH

#1

JPL EPHEMERES

D-11597

6/24/52-4/20/70

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0097	147537746757	176546552365	604235457041	601324365626	072177223637	177751162746	332354176414	600527140617
0145	104147731010	176572532722	731241334100	177561072511	062765256060	600716734230	762040634357	601315142204
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0673 173761764007 100000000000 577531056423 230442533642 175374343616 500376300000 603726572531 737777777777
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E 0001 REC 0001 CH 0168

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0097	516171676005	312405617170	644005050505	050505050505	050505050505	050505050505	050505050505	050505050505
0145	050505050505	666075776457	000030010001	000000000000				

FILE 0001 REC 0002 CH 0168

0001	000031010001	204500000000	206620000000	226451734523	226452436120	204400000000	000000000000	200400000000
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0097	203500000000	203400000000	203600000000	203400000000	203700000000	203400000000	204400000000	203400000000
0145	204440000000	203400000000	172504372646	000031010001				

FILE 0001 REC 0003 CH 1512

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0097	450561643627	177055542543	522123172535	601625234473	071207623777	177664321773	352210724125	600720610027
0145	615001554161	601517564671	555555516777	600025345217	073052432746	177146204525	700110640132	601502730541
0193	344737044377	600115024221	246200407376	177055651156	532076651423	601610400302	357361127777	177675665253
0241	104217231204	600705020177	664275601601	601514256624	047503132777	600031200431	664034074114	177144652222
0289	034010643773	601431024676	516077575577	600120111145	711374151465	177055414537	134221151676	601533450352
0337	655351140177	177743140357	603466016423	600634201154	602353025113	601514160744	176167147777	600035502464
0385	736365540036	177142643067	300217567477	601416246670	431750257777	600123752235	462275126462	177054506436
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0481	160664567777	600105066315	324744520164	177140000631	174203641615	601401026732	073416436177	600130360406
0529	762040204332	177052771740	340302126341	601501251621	133771537177	177351761414	732706541615	601225345145
0577	566752450631	602122227511	245076065777	177256326556	544661053431	601521772232	104253736767	602023050453
0625	420012545377	177140361106	726000227030	176051246247	355114424514	602124452025	544542515777	177347275504
0673	630172051221	601222463470	670166307441	602134166602	473736061777	177270074146	424004357471	601433175053
0721	527742351251	602004711111	530756740377	177153732636	542272515715	602137061745	474356746477	602104273635
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0865	302644757243	602030057342	422710146377	177277766716	002161004763	601214225445	102443712637	175543072604
0913	465214770200	177345204031	175755377323	601331564327	534536672435	601720106633	060737055577	177241252262
0961	774005754274	601530405546	454751766247	602013653433	315650505777	177266165314	776333720701	601211214724
1009	154050131213	175744750211	502012062140	177351347533	654761640326	601313446100	706024520303	601705445736
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1105	765547505265	600533417570	110612142317	176371312237	507134657000	177555256300	440646221367	601034107605
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1249	205523043311	600737324053	216215424700	176153614116	621504162000	177370631335	500545616302	601226767446
1297	316520234473	175652644127	344312220000	200053646076	076133662475	600535153051	365627022706	176367560050
1345	304764653000	177673044156	670275235011	600721063167	501474422423	176241164252	122741664000	177476142025
1393	465657075136	601116474443	213330712677	175777366141	140067210000	600732432750	632552124620	176162371574
1441	532250725460	602624773764	744130237777	177345210431	371160136761	601304734202	706103502741	175655451775
1489	107544045000	177242133226	373515641015	000371000001				

FILE 0001 REC 0004 CH 1512

0001	000371000002	552451203546	601411756250	425302236461	175551207602	175542602000	600633121270	736757023631
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0097	175655451451	226326642000	177242023307	171024520703	601411763532	613006773151	175551731521	073711661000
0145	600611354270	657117001652	176350744763	571006565636	602317340632	726565517777	177343166556	503247775075
0193	601307523347	005604731261	175655033247	042023410400	177241363306	222412011153	601412507334	745532527027
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0289	177740514027	433472414477	601027351036	662605160031	175744223210	615515020700	177570503433	261435667272
0337	601134653750	276450110347	175576737532	015027317400	577701721060	207265053226	177146333110	250224273726
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0481	177146653050	726631237116	601616461735	210721347777	177641476566	120465631746	601126400325	467074413774
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0625	176347123531	705275113074	602411610162	565575217777	600611766253	017200740013	176241755775	270404266004
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0865	600610242575	770164147407	176242453210	777616575470	602522114156	064702027777	200065071460	633477000454

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E 0001 REC 0004 CH 1512

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1393 603030427324 017753577777 177076430310 722227674324 602104645126 372053567007 603200417376 042137277777
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FILE 0001 REC 0005 CH 1512

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FILE 0001 REC 0006 CH 1512

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0193 603526715115 123236003777 604335236637 315017777777 600702414615 704632512200 174455765063 023442060000
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FILE 0001 REC 0001 CH 0168

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0097	053124056171	717140050505	050505050505	050505050505	050505050505	050505050505	050505050505 050505050505
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FILE 0001 REC 0002 CH 0168

0001	000031010001	204500000000	206620000000	226452431020	226453203420	204400000000	000000000000 200400000000
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FILE 0001 REC 0003 CH 1512

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0097	277562056554	601011744751	435246344364	601425036467	673303017017	600017424461	041767352203 177240735064
0145	066045501701	601335752647	350154632177	177276530055	445774576355	601223266504	150374751065 601320116424
0193	570056126477	177460147441	724633446407	601036757570	326345034041	601423574201	676514505337 600015735433
0241	744533244276	177176266101	241661541572	601430033415	406362642777	600336471457	735233273576 176650563663
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0337	562153352077	600015231260	411207305567	177172137070	516024712324	601527035032	753502267777 600227061377
0385	440502342113	176756451620	712055243516	601333274733	543277664377	600735342614	126124725507 176241365557
0433	141506367560	601432673535	334253140477	600015446470	263044701071	177165525324	074277465014 601702465465
0481	472370163777	600137635332	252434411077	177042067623	702753200117	601402546276	717750237377 600410731111
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0673	566241216737	601317264403	320746675057	176241054465	777517344760	600416741123	446646612020 176642310554
0721	577774375110	176041333375	221440117000	600516731374	076302157257	176547253563	674347612777 175542375234
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1345	406602077777	600023343566	147017641063	177143613132	244556535221	601502336115	522332233777 600203623776
1393	105160504704	176760255716	151176423314	601625202521	735624722777	177161006306	171136744050 601426074414
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FILE 0001 REC 0004 CH 1512

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0193	176463113516	427204067111	602130360645	527510021377	600600504100	723463767577	176362345401 062550566122
0241	602230273054	376041632377	600021656600	340703647210	176772625217	040534351674	601727042563 554675347777
0289	200065563045	226455013036	600635622420	365252437210	176155413462	270076410000	177756455755 740123745202
0337	601004521705	022471352041	176047364572	654461254000	600011477173	247352250670	177042465547 460703601650
0385	601717433755	613066177777	200064061303	642135556537	600636661207	630155326236	176153666173 302457210000
0433	177755133020	525362340422	601006377114	461114564557	176046020155	450565650000	600001532115 041020555675
0481	177047500054	704430462454	601710332710	252673017777	200062153047	275375436274	600700117063 134374716657
0529	176151715076	520741454000	177753425061	526442543545	601010504206	703705152463	176044253507 100214210000
0577	600436510531	062522700724	176352263547	706452476216	602402427212	503750413777	600620102661 221272074065
0625	176176163052	024072703250	602517155473	514141467777	600726373040	555471033176	176065752420 007633245674
0673	602625547025	257726747777	600437511112	133142011252	176350751232	267455016260	602405272671 566404653777
0721	600607547461	451146333012	176244543457	303005723036	602506047107	515422677777	600717134714 215673737214
0769	176077507437	424215367300	602615555005	317445617777	600501467033	610073114756	176347251676 067366046662
0817	602410475403	105134277777	600537617440	077763356334	176252031636	055527003140	602436336325 424236247777
0865	600710076006	764721332605	176144355631	473121710676	602605635364	232455367777	577613200574 162662500535

FILE 0001 REC 0004 CH 1512

0913	176770213513	770036351130	602225210565	504044777777	177640301241	657620441301	601335357721	031602121033
0961	175365561447	371321300000	177564262303	737135775072	601410123020	751155013577	175272367704	521003640000
1009	577613133273	752147514016	176770421536	400211075320	602224427571	666656577777	177550770274	741575702267
1057	601424116573	167423012373	175364605056	770713600000	177551360012	002766014161	601423477763	025046545716
1105	175271600614	6331 73300000	577613122204	420544264675	176770601770	160526601200	602223605255	731227577777
1153	177442260273	101663575264	601533116210	603141121577	175363551134	755323100000	177475056740	100116556655
1201	601437146514	417516632777	175270747355	412020600000	601114420602	455063651036	175644144005	332026625440
1249	603224010307	316211277777	600520411643	526455135337	176062163036	013726755770	603404500421	556405777777
1297	600624452452	503155556743	175755477226	004325645260	603522325765	206725777777	601221363611	041534031702
1345	175575473100	126026710700	603217604674	746133277777	600520321251	146577037045	176062507773	320406622440
1393	603337716226	160046777777	600624306252	210273625300	175756047575	541315565120	603517250410	012231777777
1441	176350405014	670135761652	175562515654	730141553750	603213525172	601210377777	600520262122	564122456542
1489	176063030677	544721027240	403003042313	000371000002				

FILE 0001 REC 0005 CH 1512

0001	000371000003	603334367025	333614777777	600624171075	613703041401	175756415073	551421255510	603512046420
0049	331251777777	577733672740	656630135761	176146073765	605713747500	603317324714	714337777777	577431263153
0097	000127570035	176450566531	555101760400	603224066143	041777777777	577537037336	562765233243	176342554524
0145	206317217400	603333304623	556777777777	577735607146	417157326404	176144111203	350426724100	603325564716
0193	601637777777	577431255560	713313034656	176450615037	446062222600	603224424636	732777777777	577537024622
0241	644033046505	176342606076	416502725000	603333235724	011377777777	577737524015	271527273503	176142123654
0289	154372426700	603330773226	200637777777	577431250674	777073167402	176450642612	365461654000	603225200045
0337	754377777777	577537012535	006065505341	176342637004	604363202600	603333656343	124777777777	177174576773
0385	106616422500	602500727634	453670263377	174041277531	224620000000	601221427221	607366235526	175055350160
0433	153231013260	604505057531	231477777777	601224244560	271441750733	174763367526	407530436200	604310040510
0481	275267777777	177174621434	536202035237	602500574041	600221605777	173744072631	320000000000	601226507420
0529	475774476514	175054057405	475675471100	173556013716	070660000000	601226374240	001071110461	174762260153
0577	404206235300	173364752035	323240000000	177174643104	126460663207	602500452154	225270771377	173644071561
0625	260400000000	601233572422	335651116201	175052575606	411523060740	173550412255	515054000000	601230525365
0673	107544056755	174761151627	103705641100	173443346762	162570000000	577402777341	707006226556	176247747554
0721	516274704000	603437302125	567777777777	577421151142	570714654445	176175311456	777522644000	603515014632
0769	477777777777	577536443654	674612771270	176053677470	531624020000	603626762046	463777777777	577403064312
0817	452736416256	176247676352	340346340000	603526424572	367777777777	577421050262	512471726050	176175431652
0865	153152352000	603521642113	023777777777	577536351500	712150007361	176054011665	740460006000	603627441023
0913	133777777777	577403151403	013612213124	176247624664	177733014000	603604157377	477777777777	577420747500
0961	066121360022	176175551271	553335462000	603530636044	047777777777	577536257400	741373424607	176054123373
1009	545144370000	603635014462	547777777777	177064700611	707107266015	603026764132	562615612777	173777647377
1057	231140000000	600637430457	572713664663	174750235273	124226540000	173162053173	020000000000	601005576041
1105	146055322000	176465214236	245233644000	604321511711	337577777777	177065020460	145332060500	603026427544
1153	373114556777	173741124351	525330000000	600637467250	521363423643	174747737224	415420772000	173570425150
1201	403000000000	601005652006	023350456147	174644757303	774344751000	173444052477	317740000000	177065140203
1249	463620322132	603026204315	155522000777	173574244456	400300000000	600637526111	406716702455	174747464311
1297	114541014000	173563035473	253100000000	601005726064	636402477265	174644531261	232431741000	173455045726
1345	107300000000	577412430201	573372517746	175747267362	373011620000	603507340366	013777777777	577237276251
1393	653220661044	176060041435	663543320000	603530236641	577777777777	577407444261	271773266123	175751423543
1441	675524310000	603637426125	467777777777	577412524144	526110176410	175747204023	016024630000	603537142563
1489	037777777777	577237270416	606015231537	000371000003				

FILE 0001 REC 0006 CH 1512

0001	000371000004	123606667403	176060057743	354374740000	603535067123	737777777777	577407431246	713540243115
0049	175751442140	376446040000	603700221454	257777777777	577412620121	321631164705	175747116250	513446570000
0097	603625357055	677777777777	577237262570	402171274635	176060075206	235626660000	603610153576	137777777777
0145	577407416246	645735537037	175751457567	265745140000	603713157417	237777777777	177073736005	631141412254
0193	603316110741	116432717777	173777613116	600040000000	601021412460	443351511464	174373651332	132164100090
0241	173162673203	655400000000	601123701272	342354252403	174273673011	272251430000	604321547674	470277777777
0289	177073747655	265412362027	603313172321	476571217777	173741070102	620320000000	601021472531	407071470223
0337	174367232516	332414740000	173570454356	125000000000	601123752725	431713773730	174270020735	004020060000
0385	173444106743	713300000000	177073761507	561102325163	603311364363	570144517777	173574062516	274100000000
0433	601021552620	217531546455	174363277060	734336560000	173563063104	323560000000	601124024376	523320510371
0481	174264325415	610370350000	173455100570	734060000000	577721256436	103645356531	175261436316	122331000000
0529	603507407575	223377777777	577207774625	046511713646	175751356177	713014340000	603530671654	557777777777
0577	577322140374	540742655031	175641725604	362713300000	603700035760	537777777777	577722110300	514032363157
0625	175260503237	434643500000	603537211531	674777777777	577207774537	265112171642	175751400043	705171640000
0673	603535521762	337777777777	577322137606	342773203337	175641750230	731101340000	603701202653	277777777777

```
@RUN  DBH011,JPEP40,READE,STD,100/0,,CCF/2120  ;; USE READE TO GET COORDINATES

@ASG,T     10,T,02208          . D702   TYPE 50 EPHEMERIDES
```

JPL Ephemeris data program

(use READE to get points)

See pages 26-28 of 'JPL Development Ephemeris Number 69' for description of this program.

```
@FOR,IS    MAIN,MAIN
CYCLE 000 COMPILED BY 1701 STS-E ON 17 JAN 73 AT 15:29:20.


    MAIN PROGRAM

    STORAGE USED: CODE(1) 000174; DATA(7) 000053; BLANK COMMON(2) 000000

     COMMON BLOCKS:

     0003   CETBL1 000010
     0004   CETBL2 000017
     0005   CETBL4 000230
     0006   CETBL5 000234
     0007   REC1   000030
     0010   REC2   000031

    EXTERNAL REFERENCES (BLOCK, NAME)

     0011   READS
     0012   NINTR$
     0013   NWDU$
     0014   NIO1$
     0015   NIO2$
     0016   NSTOP$

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

     0000   000013 1000F      0000   000017 1001F      0000   000021 1002F      0001   000023 1256       0001   000041 1346
     0001   000053 1476       0001   000060 1510       0001   000106 1630       0001   000106 1650       0001   000120 1750
     0000   000023 2000F      0000   000025 2001F      0001   000126 2030       0001   000140 2110       0003 D 000000 AU
     0010 D 000000 B          0007 D 000000 BCD        0006 D 000000 BTVECT     0003 D 000006 EMRAT       0000 I 000007 I
     0004 I 000001 ICENTR     0004 D 000000 ICW        0000 I 000000 IERR        0004 I 000002 IREQ        0000 I 000010 I$
     0000 I 000012 J          0000 D 000000 JED        0000 D 000004 JED1        0000 I 000011 K           0005 D 000220 NUT
     0003 D 000002 RE         0005 D 000000 TABOUT     0003 D 000004 TPD         0000 D 000002 TSEC


00101      1*          DOUBLE PRECISION JED,TSEC,AU,RE,TPD,EMRAT,TABOUT(6,12),NUT(4)
00103      2*          DOUBLE PRECISION BTVECT(6,13),JED1
00104      3*          REAL BCD(24),B(25)
00105      4*          INTEGER IERR,ICW,ICENTR,IREQ(17)
00106      5*          COMMON/CETBL1/ AU,RE,TPD,EMRAT
00107      6*          COMMON/CETBL2/ ICW,ICENTR,IREQ
00110      7*          COMMON/CETBL4/ TABOUT,NUT
00111      8*          COMMON/CETBL5/ BTVECT
00112      9*          COMMON/REC1/BCD
00113     10*          COMMON/REC2/B
00114     11*          JED=2473280.500
00115     12*          TSEC=0.D0
00116     13*          AU=1.000
00117     14*          RE=4.263F287F5D-5
00120     15*          TPD=1.D0
00121     16*          EMRAT=81.30150
```

```
00122    17*          ICW=1
00123    18*          ICENTR=10
00124    19*          DO 10 I=1,13
00127    20*       10 IREQ(I)=2
00131    21*          CALL READF(JED,TSEC,IERR)
00132    22*          WRITE (6,1000) BCD
00140    23*     1000 FORMAT (1H1,12A6/1H ,12A6)
00141    24*          WRITE (6,1001) B
00147    25*     1001 FORMAT (5E16.8)
00150    26*          DO 20 K=1,60
00153    27*          CALL READF (JED,TSEC,IERR)
00154    28*          JED1=JED + TSEC/86400.00
00155    29*          WRITE (6,1002) JED1
00160    30*     1002 FORMAT (1H1,F25.18)
00161    31*          WRITE (6,2000) ((TABOUT(I,J),I=1,6),J=1,12)
00172    32*     2000 FORMAT (3D26.18)
00173    33*          WRITE (6,2001) NUT
00201    34*     2001 FORMAT (4D26.18)
00202    35*          DO 30 I=1,6
00205    36*       30 BIVECT(I,10)=BIVECT(I,10)/2E
00207    37*          WRITE (6,2000) (BIVECT(I,10),I=1,6)
00215    38*          TSEC=TSEC + 0.12500*86400.00
00216    39*       20 CONTINUE
00220    40*          STOP
00221    41*          END

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
@FOR,IS    GETTP4,GETTP4
CYCLE 000 COMPILED BY 1201 S7F-8 ON 07 JAN 73 AT 15:23:20.

    SUBROUTINE GETTAP    ENTRY POINT 000233

    STORAGE USED: CODE(1) 000241; DATA(6) 000036; BLANK COMMON(2) 000000

     COMMON BLOCKS:

     0003   CETBL2 000617
     0004   CETBL3 002507
     0005   CETBL9 000007
     0006   REC1   000030
     0007   REC2   000031

    EXTERNAL REFERENCES (BLOCK, NAME)

     0010   NREW$
     0011   NRBU$
     0012   NIO1$
     0013   NIO2$
     0014   NBSP$
     0015   NERR3$

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

     0001   000030 133C      0001   000041 141C      0001   000064 153C      0001   000071 157C      0001   000057 30L
     0001   000101 35L       0001   000011 4L        0001   000120 40L       0001   000016 5L        0001   000123 50L
     0001   000136 55L       0001   000020 6L        0001   000154 60L       0001   000172 64L       0001   000046 7L
     0001   000205 70L       0007 C 000002 AJD       0007 R 000003 BJD       0004 R 003506 CKSUM     0000 D 000005 DSTEP
     0007   000006 DUM20     0003   000001 ICENT     0003 I 000000 ICW       0005 I 000006 IERR1     0000 I 000007 IM
     0000   000021 INJP$     0003   000002 IREC      0000 I 000010 I$        0000 D 000003 JDF       0000 D 000001 JDI
     0005 D 000004 JDIF      0000 I 000013 JDIG      0005 D 000000 JD1       0000 D 000011 JFWD      0000 I 000000 LOC
     0004 I 003172 NUTAT     0000 D 000000 REC1      0007 R 000000 REC2      0005 R 000004 SJDIF     0000 R 000013 SJDIG
     0000 R 000011 SJFWD     0007 C 000004 STEP      0004 D 000000 TAB3      0007   000000 TBODY     0005 D 000002 TDAY
     0007   000001 TYPE

00100      1*    C       GETTA.                    GET EPHEMERIS RECORD FROM TAPE                    GET00100
00101      2*          SUBROUTINE GETTAP                                                             GET00200
00101      3*    C     J.E. EKELUND, MESA SCIENTIFIC CORP., 1965 SEPT 15                             GET00300
00101      4*    C     C.L. LAWSON, JPL, 1965 NOV 17                                                 GET00400
00101      5*    C                                                                                   GET00500
00101      6*    C     THIS SUBROUTINE FETCHES FROM THE JPL EPHEMERIS TAPE THE                       GET00600
00101      7*    C     DATA RECORD CONTAINING THE DATE,(JD1+TDAY)                                    GET00700
00101      8*    C        EPHEMERIS TAPE MUST BE MOUNTED ON UNIT 10                                  GET00800
00101      9*    C                                                                                   GET00900
00101     10*    C *   COMMON BLOCK  CETBL2  *                                                       GET01000
00101     11*    C     ICW       FLAG INDICATING STATUS OF COMMON BLOCKS REC2 AND CETBL3            GET01100
00101     12*    C               1 MEANS NEITHER BLOCKS CONTAIN VALID DATA                           GET01200
00101     13*    C               2 MEANS BOTH BLOCKS CONTAIN VALID DATA                              GET01300
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00101    14*    C              3 MEANS REC2 IS VALID, GETEL3 IS NOT                          GET01400
00101    15*    C              USED MUST SET ICW=1 BEFORE INITIAL CALL                       GET01500
00101    16*    C *  COMMON BLOCK GETBL3 *                                                  GET01600
00101    17*    C    TAB3 839 DOUBLE PREC. WORD BUFFER TO ACCOMODATE  J.D. AND EPHEMERIS.  GET01700
00101    18*    C    NUTAT 204 SINGLE PREC. WORD BUFFER TO ACCOMODATE NUTATION DATA.       GET01800
00101    19*    C    CKSUM 1 S.P. WORD FOR CHECKSUM.                                       GET01900
00101    20*    C                                                                          GET02000
00101    21*    C      THE COMMON BLOCK 'GETBL3' IS FOR COMMUNICATION                      GET02100
00101    22*    C      BETWEEN GDEP3 AND GETR3.                                            GET02200
00101    23*    C      JD1       REFERENCE JULIAN EPHEMERIS DATE.                          GET02300
00101    24*    C      TDAY      DAYS OF EPHEMERIS TIME PAST JD1                           GET02400
00101    25*    C      JDIF      DIFFERENCE IN DAYS BETWEEN REQUESTED DATE AND INITIAL     GET02500
00101    26*    C                DATE OF CURRENT EPHEMERIS TAPE RECORD.                    GET02600
00101    27*    C      IERR1     ERROR FLAG                                                GET02700
00101    28*    C                =ZERO ERROR                                               GET02800
00101    29*    C                1=(JED+TSEC/86400.D0) LESS THAN FIRST DATE                GET02900
00101    30*    C                   ON TAPE                                                GET03000
00101    31*    C                2=(JED+TSEC/86400.D0) GREATER THAN LAST DATE              GET03100
00101    32*    C                   ON TAPE                                                GET03200
00101    33*    C                                                                          GET03300
00101    34*    C *   COMMON BLOCK    REC1   *                                             GET03400
00101    35*    C      REC1          24 BCD WORDS OF EPHEMERIS TAPE IDENTIFICATION         GET03500
00101    36*    C *  COMMON BLOCK  REC2                                                   GET03600
00101    37*    C    TBODY  FL.PT. WORD   REPRESENTING NUMBER OF BODIES CONTAINED IN       GET03700
00101    38*    C           EPHEMERIS DATA.                                                GET03800
00101    39*    C    TYPE   TYPE OF EPHEMERIS TAPE.   THIS IS NOT USED.                    GET03900
00101    40*    C    AJD    SINGLE PREC. INITIAL JULIAN DATE OF  DATA.                     GET04000
00101    41*    C    BJD    SINGLE PREC.       INITIAL DATE OF FINAL DATA RECORD.          GET04100
00101    42*    C    STEP   STEP SIZE OF LOGICAL DATA RECORD.                              GET04200
00101    43*    C                                                                          GET04300
00103    44*           COMMON/GETBL3/ICW,ICENT  ,TREC(13)                                  GET04400
00104    45*           COMMON /GETBL3/ TAB3(839), NUTAT(204), CKSUM                        GET04500
00105    46*           COMMON/GETBL3/JD1,TDAY,JDIF,IERR1                                   GET04600
00106    47*           COMMON/REC1/REC1(24)                                                GET04700
00107    48*           COMMON/REC2/TBODY,TYPE,AJD,BJD,STEP,DUM20(20)                       GET04800
00110    49*           REAL REC2(25)                                                       GET04900
00111    50*           DOUBLE PRECISION TAB3, JD1,JDF,                JFWD,DSTEP           GET05000
00112    51*           DOUBLE PRECISION JD1,TDAY,JDTF,JDIG                                 GET05100
00113    52*           EQUIVALENCE (JFWD,SJFWD),(JDIF,SJDIF),(REC2,TBODY),(JDIG,SJDIG)     GET05200
00114    53*           DATA IM/10/                                                         GET05300
00114    54*    C                                                                          GET05400
00116    55*           IERR1=0                                                             GET05500
00116    56*    C                                    GO TO (5,35,7),ICW                    GET05600
00117    57*           IF(ICW-1)4,5,2                                                      GET05700
00122    58*         2 IF(ICW-3)35,7,4                                                     GET05800
00125    59*         4 IERR1=5                                                             GET05900
00126    60*           RETURN                                                              GET06000
00127    61*         5 ASSIGN 7 TO LCC                                                     GET06100
00130    62*         8 REWIND IM                                                           GET06200
00131    63*           READ(IM)REC1                                                        GET06300
00137    64*           READ(IM)REC2                                                        GET06400
00145    65*           GO TO LCC,(7,30)                                                    GET06500
00146    66*     7     JDF=BJD+STEP                                                        GET06600
00147    67*           JD1=AJD                                                             GET06700
00150    68*           DSTEP=STEP                                                          GET06800
00150    69*    C                                                                          GET06900
00150    70*    C                              READ EPHEMERIS DATA RECORD                  GET07000
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```
00150    71*    C
00151    72*        30 READ(IM)TAB3                    ,NUTAT,CKSUM                    GET07100
00164    73*           ICW =2                                                           GET07200
00165    74*        35 JDIF=(JD1-TAB3(1))+TDAY                                          GET07300
00166    75*           IF(SJDIF)60,40,37                                                GET07400
00171    76*     37    JDIG=JDIF-DSTEP                                                  GET07500
00172    77*           IF(SJDIG)40,40,50                                                GET07600
00172    78*    C                                                                       GET07700
00172    79*    C                              RETURN IF (JD1+TDAY) IS IN CURRENT RECORD. GET07800
00172    80*    C                                                                       GET07900
00175    81*     40    RETURN                                                           GET08000
00175    82*    C                                                                       GET08100
00175    83*    C                              (JD1+TDAY) IS LATER THAN CURRENT RECORD  GET08200
00175    84*    C                                                                       GET08300
00176    85*        50 IF(TDAY .LE. JDF-JD1) GO TO 52                                   GET08400
00200    86*           IERR1=2                                                          GET08500
00201    87*           RETURN                                                           GET08600
00202    88*        52 JDTG=JDIG-DSTEP                                                  GET08700
00203    89*           IF(SJDIG)30,70,55                                                GET08800
00206    90*        55 READ(IM)TAB3(1)                                                  GET08900
00211    91*           GO TO 52                                                         GET09000
00211    92*    C                                                                       GET09100
00211    93*    C                              (JD1+TDAY) IS EARLIER THAN CURRENT RECORD GET09200
00211    94*    C                                                                       GET09300
00212    95*        60  JFWD=(JD1-JDI)+TDAY                                            GET09400
00213    96*           IF(SJFWD)62,64,64                                                GET09500
00216    97*        62 IERR1=1                                                          GET09600
00217    98*           RETURN                                                           GET09700
00217    99*    C                                                                       GET09800
00217   100*    C                      DECIDE WHETHER TO BACKSPACE OR REWIND            GET09900
00217   101*    C                                                                       GET10000
00220   102*        64 IF(4.687*SJDIF .GT. 33.144 - SJFWD) GO TO 70                     GET10100
00220   103*    C                                                                       GET10200
00220   104*    C                                  REWIND AND READ FORWARD              GET10300
00220   105*    C                                                                       GET10400
00222   106*           ASSIGN 30 TO LOC                                                 GET10500
00223   107*           GO TO 6                                                          GET10600
00223   108*    C                                                                       GET10700
00223   109*    C                                  BACKSPACE                            GET10800
00223   110*    C                                                                       GET10900
00224   111*        70 BACKSPACE IM                                                     GET11000
00225   112*           IF(SJDIF)74,73,30                                                GET11100
00230   113*     74    JDIF=JDIF+DSTEP                                                  GET11200
00231   114*           GO TO 70                                                         GET11300
00232   115*           END                                                              GET11400
                                                                                       GET11500

END OF COMPILATION:        NO  DIAGNOSTICS.
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&FOR,IS    READE,READE
CYCLE 000 COMPILED BY 1201 STF-5 ON 07 JAN 72 AT 15:29:31.

   SUBROUTINE READE     ENTRY POINT 001027

   STORAGE USED: CODE(1) 001043; DATA(1) 000244; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   CETBL1 000010
    0004   CETBL2 000017
    0005   CETBL3 002567
    0006   CETBL4 000230
    0007   CETEL5 000234
    0010   CETBL9 000007

   EXTERNAL REFERENCES (BLOCK, NAME)

    0011   GETTAP
    0012   NERR2$
    0013   NERR3$

   STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001   000032 19L       0001   000034 147B      0001   000067 183B      0001   000244 165L      0001   000254 169L
    0001   000256 172L      0001   000255 20L       0001   000264 200L      0001   000334 201L      0001   000155 205B
    0001   000361 209L      0001   000400 220L      0001   000410 222L      0001   000231 226B      0001   000456 226L
    0001   000476 232L      0001   000515 240L      0001   000305 252B      0001   000350 262B      0001   000140 28L
    0001   000424 310B      0001   000465 317B      0001   000144 32L       0001   000534 345B      0001   000554 355B
    0001   000641 370B      0001   000655 376B      0001   000543 4020L     0001   000622 4028L     0001   000624 4032L
    0001   000645 4040L     0001   000661 4043L     0001   000664 4052L     0001   000667 4056L     0001   000671 4060L
    0001   000676 4064L     0001   000706 4068L     0001   000721 4076L     0001   000725 4080L     0001   000727 4084L
    0001   000732 4088L     0001   000737 4092L     0001   000756 4100L     0001   001004 4104L     0001   000715 415B
    0001   000752 425B      0001   001000 442B      0001   001006 5000L     0002 D 000000 AU        0002 D 000000 BIVECT
    0000 D 000150 C         0005   003580 CKSUM     0003 D 000006 EMRAT     0000 D 000132 FAC       0000 I 000155 I
    0000 I 000162 IFARY     0000 T 000184 IFBDY     0004 I 000001 ICENT     0004   000000 ICW       0000 I 000170 IG1
    0000 I 000173 IG2       0010 T 000000 IERR1     0000 I 000172 IGET      0000 I 000167 IGET1     0000 I 000171 IGET2
    0000 I 000174 IMAX      0000   000223 INJP$     0000 I 000167 IFOS      0004 I 000002 IREQ      0000 I 000165 IU
    0000 I 000102 IVEL      0000 T 000154 I$        0010 D 000004 JDIF      0010 D 000000 JD1       0000 I 000154 JREQ
    0000 I 000176 KASE      0000 I 000175 KCENT     0000 I 000165 KK        0000 I 000001 KREQ      0000 I 000177 K1
    0000 I 000200 K2        0000 T 000161 LLNAR     0000 I 000201 L2        0000 I 000160 MAXALL    0000 I 000157 MAXEM
    0000 I 000156 MAXPL     0010 I 000015 MCENT     0000 I 000030 M1        0006 D 000220 NUT       0005 R 003172 NUTAT
    0000 D 000130 PAT       0003 D 000002 PI        0000 R 000193 SAVE      0000 R 000115 STP       0006 D 000000 TAEOUT
    0005 D 000000 TAB3      0010 D 000002 TDAY      0000 D 000152 TEMP      0003 D 000004 TPD       0000 D 000134 U
    0000 L 000000 WFLAG

00100      1*    C       READE.                    READ,INTERPOLATE,TRANSLATE JPL EPHEMERIS  RDE00100
00101      2*          SUBROUTINE READE(JED,TSEC,IERR)                                     RDE00200
00101      3*    C     J.E. EKELUND, MESA SCIENTIFIC CORP., 1965 SEPT 15                   RDE00300
00101      4*    C     C.L. LAWSON, JPL, 1966 MAR 17                                       RDE00400
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00101     4*    C     READ JPL EPHEMERIS AT THE JULIAN EPHEMERIS DATE                    RDE00500
00101     5*    C     GIVEN BY (JED+TSEC/86400.D0)                                       RDE00600
00101     7*    C                                                                        RDE00700
00101     8*    C**   ITEMS COMMUNICATED THROUGH THE CALLING SEQUENCE **                 RDE00800
00101     9*    C                                                                        RDE00900
00101    10*    C     JED       REFERENCE JULIAN EPHEMERIS DATE.                         RDE01000
00101    11*    C     TSEC      SECONDS OF EPHEMERIS TIME PAST JED.                      RDE01100
00101    12*    C               ANY COMBINATION OF VALUES OF JED AND TSEC                RDE01200
00101    13*    C               IS ACCEPTABLE AS LONG AS (JED+TSEC/86400.D0)             RDE01300
00101    14*    C               IS WITHIN THE RANGE OF THE EPHEMERIS TAPE                RDE01400
00101    15*    C               BEING USED. HOWEVER TO OBTAIN THE                        RDE01500
00101    16*    C               FINEST POSSIBLE RESOLUTION IN INTERPOLATION              RDE01600
00101    17*    C               THE NUMBER JED MUST BE AN EXACT MACHINE                  RDE01700
00101    18*    C               NUMBER. FOR EXAMPLE JED COULD BE A DATE ENDING           RDE01800
00101    19*    C               WITH .0 OR .5 .                                          RDE01900
00101    20*    C     IERR      ERROR FLAG                                               RDE02000
00101    21*    C               0=NO ERROR                                               RDE02100
00101    22*    C               1=(JED+TSEC/86400.D0) LESS THAN FIRST DATE               RDE02200
00101    23*    C                  ON TAPE                                               RDE02300
00101    24*    C               2=(JED+TSEC/86400.D0) GREATER THAN LAST DATE             RDE02400
00101    25*    C                  ON TAPE                                               RDE02500
00101    26*    C               3=SOME IRSC(I) IS NOT 0,1, OR 2                          RDE02600
00101    27*    C               4=ICENT   IS NOT IN THE RANGE 1 THRU 11                  RDE02700
00101    28*    C               5=ICW IS NOT 1,2, OR 3                                   RDE02800
00101    29*    C                                                                        RDE02900
00101    30*    C** THE FOLLOWING ITEMS ARE INPUT THROUGH COMMON **                      RDE03000
00101    31*    C *   COMMON BLOCK CETBL1 *                                             RDE03100
00101    32*    C     AU          A.U. EXPRESSED IN DESIRED OUTPUT UNITS               RDE03200
00101    33*    C     RE          EQUATORIAL RADIUS OF EARTH IN DESIRED OUTPUT UNITS   RDE03300
00101    34*    C                 RE IS USED TO SCALE THE LUNAR EPHEMERIS              RDE03400
00101    35*    C     TRD           DESIRED NUMBER OF TIME UNITS PER DAY               RDE03500
00101    36*    C     EMRAT     EARTH MOON MASS RATIO. SUGGESTED VALUE=81.300          RDE03600
00101    37*    C                                                                        RDE03700
00101    38*    C     SUGGESTED VALUES FOR AU AND RE  DEPEND UPON                      RDE03800
00101    39*    C     DESIRED OUTPUT UNITS AS FOLLOWS..                                RDE03900
00101    40*    C     FOR OUTPUT IN EARTH RADII AU=23454.7940012251170D0, RE =1.D0     RDE04000
00101    41*    C     FOR OUTPUT IN KILOMETERS  AU=149598640.D0,          RE =6378.169D0 RDE04100
00101    42*    C     FOR OUTPUT IN A.U.  AU=1.D0,  RE =4.2675207111500850D0-5         RDE04200
00101    43*    C                                                                      RDE04300
00101    44*    C     SET TRD=86400.D0 FOR VELOCITY IN LINEAR UNITS PER SECOND.        RDE04400
00101    45*    C     SET TRD=   1.D0 FOR VELOCITY IN LINEAR UNITS PER DAY.            RDE04500
00101    46*    C                                                                      RDE04600
00101    47*    C *   COMMON BLOCK CETBL2 *                                           RDE04700
00101    48*    C     ICW       FLAG INDICATING STATUS OF COMMON BLOCKS REC2 AND CETBL3 RDE04800
00101    49*    C               1 MEANS NEITHER BLOCKS CONTAIN VALID DATA              RDE04900
00101    50*    C               2 MEANS BOTH BLOCKS CONTAIN VALID DATA                 RDE05000
00101    51*    C               3 MEANS REC2 IS VALID, CETBL3 IS NOT                   RDE05100
00101    52*    C               USER MUST SET ICW=1 BEFORE INITIAL CALL                RDE05200
00101    53*    C     ICENTR    SPECIFIES CENTRAL BODY FOR COORDINATE                  RDE05300
00101    54*    C               TRANSLATION AS FOLLOWS..                               RDE05400
00101    55*    C                1 MERC     5 JUP      9 PLUTO                        RDE05500
00101    56*    C                2 VENUS    6 SAT     10 SUN                          RDE05600
00101    57*    C                3 EARTH    7 URANUS  11 MOON                         RDE05700
00101    58*    C                4 MARS     8 NEP                                     RDE05800
00101    59*    C     IRSC()    IRSC(J) SPECIFIES OUTPUT DESIRED FOR                   RDE05900
00101    60*    C               BODY NO. J.                                            RDE06000
00101    61*    C               IRSC(J)=0 NO OUTPUT                                    RDE06100
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00101    62*    C                          1 POSITION                                                    RDE06200
00101    63*    C                          2 POSITION AND VELOCITY                                       RDE06300
00101    64*    C                  J RUNS FROM 1 TO 11 AS FOLLOWS..                                      RDE06400
00101    65*    C                   1 MERC      5 JUP       9 PLUTO                                      RDE06500
00101    66*    C                   2 VENUS     6 SAT      10 SUN                                        RDE06600
00101    67*    C                   3 EARTH     7 URANUS   11 MOON                                       RDE06700
00101    68*    C                   4 MARS      8 NEP      12 ERTH-MN-BARYCENTER                        RDE06800
00101    69*    C                                          13 NUTATION                                   RDE06900
00101    70*    C *  COMMON BLOCK CETBL2 *                                                              RDE07000
00101    71*    C    TAB3 829 DOUBLE PREC. WORD BUFFER TO ACCOMODATE  J.D. AND EPHEMERIS.               RDE07100
00101    72*    C    NUTAT 204 SINGLE PREC. WORD BUFFER TO ACCOMODATE NUTATION DATA.                    RDE07200
00101    73*    C    CKSUM 1 S.P. WORD FOR CHECKSUM.                                                    RDE07300
00101    74*    C** THE FOLLOWING ITEMS ARE OUTPUT THROUGH COMMON **                                    RDE07400
00101    75*    C *  COMMON BLOCK CETBL4 *                                                             RDE07500
00101    76*    C      TABOUT( , )  PLANETARY AND LUNAR OUTPUT, SCALED AND                           RDE07600
00101    77*    C        TRANSLATED WITH RESPECT TO CENTER.                                          RDE07700
00101    78*    C                   TABOUT (I,J) CONTAINS OUTPUT FOR                                 RDE07800
00101    79*    C                   BODY NO. J. (1 .LE. J .LE. 12)                                   RDE07900
00101    80*    C                   THE INDEX I IDENTIFIES COMPONENTS AS FOLLOWS..                   RDE08000
00101    81*    C                   1=X        2=Y       3=Z                                         RDE08100
00101    82*    C                   4=XDOT     5=YDOT    6=ZDOT                                      RDE08200
00101    83*    C      NUT( )       NUTATION OUTPUT                                                  RDE08300
00101    84*    C                   NUT(1)=DELTA LONGITUDE                                           RDE08400
00101    85*    C                   NUT(2)=DELTA OBLIQUITY                                           RDE08500
00101    86*    C                   NUT(3)=TIME DERIVATIVE OF NUT(1)                                 RDE08600
00101    87*    C                   NUT(4)=TIME DERIVATIVE OF NUT(2)                                 RDE08700
00101    88*    C *  COMMON BLOCK CETBL3 *                                                            RDE08800
00101    89*    C      BIVECT( , )  WORKING ARRAY. CONTENTS ARE INTERPOLATED                         RDE08900
00101    90*    C                   AND SCALED BUT NOT TRANSLATED. 1ST INDEX RUNS                    RDE09000
00101    91*    C                   OVER X,Y,Z,XDOT,YDOT,ZDOT AS IN TABOUT                           RDE09100
00101    92*    C                   BUT 2ND INDEX IS DIFFERENT AS FOLLOWS..                          RDE09200
00101    93*    C                BODIES 1 THRU 9 ARE HELIOCENTRIC.                                   RDE09300
00101    94*    C                   1 MERC      5 JUP       9 PLUTO                                  RDE09400
00101    95*    C                   2 VENUS     6 SAT      10 MOON REL TO EARTH                      RDE09500
00101    96*    C                   3 ERTHMN    7 URANUS   11 ERTHMN REL TO EARTH                    RDE09600
00101    97*    C                   4 MARS      8 NEP      12 ERTHMN REL TO MOON                     RDE09700
00101    98*    C                                          13 SEE 4092+                              RDE09800
00101    99*    C                                                                                    RDE09900
00101   100*    C      THE COMMON BLOCK 'CETBL3' IS FOR COMMUNICATION                                RDE10000
00101   101*    C      BETWEEN PEPC AND SETR2.                                                       RDE10100
00103   102*           COMMON /CETBL1/          AU,RE,TPD,EMRAT                                      RDE10200
00104   103*           COMMON/CETBL2/ICW,ICENT  ,TEPO(12)                                            RDE10300
00105   104*           COMMON /CETBL3/ TAB3(829),NUTAT(204),CKSUM                                    RDE10400
00106   105*           COMMON/CETBL4/TABOUT(6,12),NUT(4)                                             RDE10500
00107   106*           COMMON /CETBL5/ BIVECT( 6,13)                                                 RDE10600
00110   107*           COMMON/CETBL6/JD1,TDAY,JDTF,TEPD1                                             RDE10700
00111   108*           LOGICAL WFLAG                                                                 RDE10800
00112   109*           INTEGER KREQ(12),MCENT(11),M1(21),JREC(11), IPOS(11),IVEL(11)                 RDE10900
00113   110*           REAL NUTAT ,STP(11)                                                           RDE11000
00114   111*           DOUBLE PRECISION      AU,RE,EMRAT,  TPD,TABS,BIVECT,TABOUT,NUT                RDE11100
00115   112*           DOUBLE PRECISION JD1,TDAY,JDTF ,JED                                           RDE11200
00116   113*           DOUBLE PRECISION TSEC,PAT, FAC,L(2,3),C,TEMP                                  RDE11300
00116   114*    C                                          FAC=1/86400                               RDE11400
00117   115*           DATA FAC/1.157407407407407D-5/                                                RDE11500
00117   116*    C                                                                                    RDE11600
00121   117*           DATA STP/ 2.,8*4.,2*.5/                                                       RDE11700
00123   118*           DATA KREQ/5,5,2,8*5,4,3,1/                                                    RDE11800
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00125   119*          DATA MCENT/15,15,0,0,15,10,5/                                    RDE11900
00127   120*          DATA M1/11,0,10,11,0,12,10,0,12,0,3,3,3,0,0,3,13,13,0,0/         RDE12000
00131   121*          DATA                                                             RDE12100
00131   122*         * IPOS  /02,032,140,200,254,308,362,416,470,524,1/                RDE12200
00131   123*         *,IVEL  /47,119,173,227,281,335,389,443,497,677,103/              RDE12300
00131   124*    C                                                                     RDE12400
00134   125*          JD1=JED                                                          RDE12500
00135   126*          TDAY=TSEC*FAC                                                    RDE12600
00135   127*    C                                                                     RDE12700
00136   128*          CALL SETTAP                                                      RDE12800
00136   129*    C                                                                     RDE12900
00137   130*          IF(IERR1 .NE. 0) GO TO 5000                                      RDE13000
00141   131*          IF(ICENT .GE. 1 .AND. ICENT .LE. 11) GO TO 10                    RDE13100
00143   132*          IERR1=4                                                          RDE13200
00144   133*          GO TO 5000                                                       RDE13300
00145   134*       10 CONTINUE                                                         RDE13400
00145   135*    C                                                                     RDE13500
00145   136*    C                                    SET JREQ( )TO CONTROL INTERPOLATION RDE13600
00146   137*          DO 20 I=1,10                                                     RDE13700
00151   138*          IF(IREQ(I) .GE. 0 .AND. IREQ(I) .LE. 2) GO TO 20                 RDE13800
00153   139*          IERR1=7                                                          RDE13900
00154   140*          GO TO 5000                                                       RDE14000
00155   141*       20 JREQ(I)=IREQ(I)                                                  RDE14100
00155   142*    C                                    BARYCENTER FLAG                  RDE14200
00157   143*          JREQ(3)=IREQ(12)                                                 RDE14300
00160   144*          MAXPL=JREQ(1)                                                    RDE14400
00161   145*          DO 24 I=2,10                                                     RDE14500
00164   146*       24 MAXPL=MAXO(MAXPL,JREQ(I))                                        RDE14600
00166   147*          MAXEM=MAXO(IREQ(2),IREQ(11))                                     RDE14700
00167   148*          MAXALL=MAXO(MAXPL,MAXEM)                                         RDE14800
00170   149*          IF(ICENT.EQ.3.OR.ICENT.EQ.11) GO TO 28                           RDE14900
00170   150*    C                                    CENTER IS NOT EARTH OR MOON      RDE15000
00170   151*    C                                    10=MOON,3=EARTHMN                RDE15100
00172   152*          JREQ(10)=MAXEM                                                   RDE15200
00173   153*          JREQ(3)=MAXO(JREQ(3),MAXEM)                                      RDE15300
00174   154*          JREQ(ICENT)=MAXALL                                               RDE15400
00175   155*          GO TO 32                                                         RDE15500
00175   156*    C                                                                     RDE15600
00175   157*    C                                    CENTER IS EARTH OR MOON          RDE15700
00175   158*    C                                    10=MOON,3=EARTHMN                RDE15800
00176   159*       28 JREQ(10)=MAXALL                                                  RDE15900
00177   160*          JREQ(3)=MAXPL                                                    RDE16000
00200   161*       32 JREQ(11)=IREQ(12)                                                RDE16100
00201   162*          LUNAR=JREQ(10)                                                   RDE16200
00202   163*          IBARY=JREQ(3)*3                                                  RDE16300
00202   164*    C                                                                     RDE16400
00202   165*    C                                    JREQ( )IS NOW SET                RDE16500
00202   166*    C                                                                     RDE16600
00203   167*          SAVE=0.                                                          RDE16700
00204   168*          DO 240 IBODY=1,11                                                RDE16800
00207   169*          IF(JREQ(IBODY)) 240,240,40                                       RDE16900
00207   170*    C     IF(STP(IBODY).EQ.SAVE) GO TO 165                                 RDE17000
00212   171*       40 IF(STP(IBODY) .LE. SAVE .AND. STP(IBODY) .GE. SAVE) GO TO 165    RDE17100
00214   172*          SAVE=STP(IBODY)                                                  RDE17200
00215   173*      160 TEMP=JDIF/SAVE                                                   RDE17300
00216   174*          KK=TEMP                                                          RDE17400
00217   175*          U(1,1)=TEMP-FLOAT(KK)                                            RDE17500
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00220   176*          IF(U(1,1))161,165,161                                    RDE17600
00223   177*      161 CONTINUE                                                 RDE17700
00224   178*          U(2,1)=1.DO-U(1,1)                                       RDE17800
00225   179*          DO 163 IU=1,2                                            RDE17900
00230   180*          U(IU,3)=U(IU,2)*U(IU,1)                                  RDE18000
00231   181*          U(IU,2)=(U(IU,3)-1.DO)/6.D0                              RDE18100
00232   182*      163 U(IU,3)=(U(IU,3)-4.DO)/20.DO                             RDE18200
00234   183*      165 IF(IBODY-10) 169,167,220                                 RDE18300
00237   184*      167 C=RE                                                     RDE18400
00240   185*          GO TO 170                                                RDE18500
00241   186*      169 C=AU                                                     RDE18600
00241   187*    C                                  INTERPOLATE IBODY=1,2,...,10 RDE18700
00242   188*      172 IGET1=IPOS(IBODY)+KK*9                                   RDE18800
00243   189*          IC1=1                                                    RDE18900
00244   190*      200 CONTINUE                                                 RDE19000
00245   191*          IF(U(1,1))207,201,203                                    RDE19100
00250   192*      203 IGET2=IGET1+6                                            RDE19200
00251   193*          DO 204 IGET=IGET1,IGET2,3                                RDE19300
00254   194*          BIVECT(IC1,IBODY)=                                       RDE19400
00254   195*         *            C*(U(2,1)*(TAB3(IGET   )+                  RDE19500
00254   196*         *               U(2,2)*(TAB3(IGET+ 1)+                  RDE19600
00254   197*         *                U(2,3)* TAB3(IGET+ 2)))+               RDE19700
00254   198*         *               U(1,1)*(TAB3(IGET+ 9)+                  RDE19800
00254   199*         *                U(1,2)*(TAB3(IGET+10)+                 RDE19900
00254   200*         *                U(1,3)* TAB3(IGET+11))) )              RDE20000
00255   201*      204 IC1=IC1+1                                                RDE20100
00257   202*          GO TO 205                                                RDE20200
00260   203*      201 IC2=IC1+2                                                RDE20300
00261   204*          DO 202 I=IC1,IC2                                         RDE20400
00264   205*          BIVECT(I,IBODY)=C*TAB3(IGET1)                            RDE20500
00265   206*      202 IGET1=IGET1+2                                            RDE20600
00267   207*      205 CONTINUE                                                 RDE20700
00270   208*          JREQ(IBODY)=JREQ(IBODY)-1                                RDE20800
00271   209*          IF(JREQ(IBODY)) 240,240,207                              RDE20900
00274   210*      207 IGET1=IVEL(IBODY)+KK*9                                   RDE21000
00275   211*          IC1=4                                                    RDE21100
00276   212*          C=C/TPD                                                  RDE21200
00277   213*          GO TO 200                                                RDE21300
00277   214*    C                                                              RDE21400
00277   215*    C                                  INTERPOLATE   IBODY=11   NUTATION RDE21500
00277   216*    C                                                              RDE21600
00300   217*      220 C=1.DO                                                   RDE21700
00301   218*          IGET1=IPOS(IBODY)+KK*6                                   RDE21800
00302   219*          IC1=1                                                    RDE21900
00303   220*      222 IGET2=IGET1+2                                            RDE22000
00304   221*      225 IF(U(1,1))223,226,228                                    RDE22100
00307   222*      228 DO 230 IGET=IGET1,IGET2,3                                RDE22200
00312   223*          NUT(IC1)=                                                RDE22300
00312   224*         *    C*(U(2,1)*(NUTAT(IGET   )+                         RDE22400
00312   225*         *       U(2,2)*(NUTAT(IGET+1)+                          RDE22500
00312   226*         *       U(2,3)* NUTAT(IGET+2)))+                        RDE22600
00312   227*         *       U(1,1)*(NUTAT(IGET+6)+                          RDE22700
00312   228*         *       U(1,2)*(NUTAT(IGET+7)+                          RDE22800
00312   229*         *       U(1,3)* NUTAT(IGET+8))) )                       RDE22900
00313   230*      230 IC1=IC1+1                                                RDE23000
00315   231*          GO TO  222                                               RDE23100
00316   232*      226 DO 227 IGET=IGET1,IGET2,3                                RDE23200
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00321   233*          NUT(IC1)=C*NUTAT(ICET)                                          RDE23300
00322   234*      227 IC1=IC1+1                                                       RDE23400
00324   235*      232 CONTINUE                                                        RDE23500
00325   236*          JREQ(IBODY)=JREQ(IBODY)-1                                       RDE23600
00326   237*          IF(JREQ(IBODY)) 240,240,23?                                     RDE23700
00331   238*      230 C=C/TPD                                                         RDE23800
00332   239*          ICET1=IVEL(IBODY)+KK*6                                          RDE23900
00333   240*          IC1=3                                                           RDE24000
00334   241*          GO TO 222                                                       RDE24100
00335   242*      240 CONTINUE                                                        RDE24200
00335   243*    C                                                                     RDE24300
00335   244*    C                                  INTERPOLATION IS FINISHED          RDE24400
00335   245*    C                                 RESULTS ARE IN BIVECT( , )AND NUT( ) RDE24500
00335   246*    C                                  TEST MOON REQUEST                  RDE24600
00337   247*          IF(LUNAR    ) 4020,4020,4010                                    RDE24700
00337   248*    C                                  NOTE..EMRAT=EARTH MASS/MOON MASS   RDE24800
00337   249*    C                                 SET BIVECT( ,11)=ERTHMN CENTERED AT EARTH RDE24900
00337   250*    C                                  SET BIVECT( ,12)=ERTHMN CENTERED AT MOON RDE25000
00342   251*     4010 RAT=1.D0/(EMRAT+1.D0)                                         RDE25100
00343   252*          IMAX=LUNAR * 3                                                RDE25200
00344   253*          DO 4010 I=1,IMAX                                              RDE25300
00347   254*          BIVECT(I,11)=RAT*BIVECT(I,10)                                 RDE25400
00350   255*     4010 BIVECT(I,12)=-EMRAT*BIVECT(I,11)                              RDE25500
00350   256*    C                                                                   RDE25600
00352   257*     4020 WFLAG=.FALSE.                                                 RDE25700
00353   258*          KCENT=MCENT(ICENT)                                            RDE25800
00353   259*    C                                                                   RDE25900
00353   260*    C                                  BEGIN TRANSLATION LOOP           RDE26000
00353   261*    C                                                                   RDE26100
00354   262*          DO 4100  IBODY=1,12                                           RDE26200
00357   263*          IF(IREQ(IBODY)) 4100,4100,4024                                RDE26300
00362   264*     4024 IMAX=IREQ(IBODY)*3                                            RDE26400
00363   265*          KASE=KSTAT+KREQ(IBODY)                                        RDE26500
00364   266*          K1=M1(KASE)                                                   RDE26600
00365   267*          GO TO (4032,4040,4032,4042,4052,                              RDE26700
00365   268*         *       4032,4056,4040,4048,4056,                              RDE26800
00365   269*         *       4032,4070,4076,4040,4022,                              RDE26900
00365   270*         *       4084,4088,4088,4064,4080),KASE                         RDE27000
00365   271*    C                                                                   RDE27100
00365   272*    C                                  KASE=15                          RDE27200
00365   273*     4022 K1=IBODY                                                      RDE27300
00366   274*    C                                  KASE=1,7,8,11                    RDE27400
00367   275*     4032 DO 4036 I=1,IMAX                                              RDE27500
00372   276*     4036 TABOUT(I,IBODY)=BIVECT(I,K1)                                  RDE27600
00374   277*          GO TO 4100                                                    RDE27700
00374   278*    C                                  KASE=2,8,14                      RDE27800
00375   279*     4040 DO 4044 I=1,IMAX                                              RDE27900
00400   280*     4044 TABOUT(I,IBODY)=0.D0                                          RDE28000
00402   281*          GO TO 4100                                                    RDE28100
00402   282*    C                                  KASE=4,9                         RDE28200
00403   283*     4048 K2=3                                                          RDE28300
00404   284*          GO TO 4100                                                    RDE28400
00404   285*    C                                  KASE=5                           RDE28500
00405   286*     4052 L2=11                                                         RDE28600
00406   287*          GO TO 4060                                                    RDE28700
00406   288*    C                                  KASE=10                          RDE28800
00407   289*     4056 L2=10                                                         RDE28900
```

```
00410   290*     4060 K1=IBODY                                                                  RDE29000
00411   291*          K2=13                                                                     RDE29100
00412   292*          GO TO 4092                                                                RDE29200
00412   293*    C                                  KASE=19                                      RDE29300
00413   294*     4064 K1=ICENT                                                                  RDE29400
00413   295*    C                                  KASE=7                                       RDE29500
00414   296*     4068 DO 4072 I=1,IMAX                                                          RDE29600
00417   297*     4072 TABOUT(I,IBODY)=-BIVECT(I,K1)                                             RDE29700
00421   298*          GO TO 4100                                                                RDE29800
00421   299*    C                                  KASE=12,13                                   RDE29900
00422   300*     4076 K2=KASE-1                                                                 RDE30000
00423   301*          GO TO 4100                                                                RDE30100
00423   302*    C                                  KASE=20                                      RDE30200
00424   303*     4080 K1=IBODY                                                                  RDE30300
00424   304*    C                                  KASE=16                                      RDE30400
00425   305*     4084 K2=ICENT                                                                  RDE30500
00426   306*          GO TO 4100                                                                RDE30600
00426   307*    C                                  KASE=17,18                                   RDE30700
00427   308*     4088 L2=ICENT                                                                  RDE30800
00430   309*          K2=KASE-6                                                                 RDE30900
00431   310*     4092 IF(WFLAG) GO TO 4100                                                      RDE31000
00433   311*          WFLAG=.TRUE.                                                              RDE31100
00433   312*    C                                                                              RDE31200
00433   313*    C                                  BIVECT( ,13)IS AN AUXILIARY VECTOR          RDE31300
00433   314*    C                                  NEEDED WHEN KASE=5,10,17,18.                RDE31400
00433   315*    C              FOR KASE=05    BIVECT( ,13)=EARTH  CENTERED AT SUN             RDE31500
00433   316*    C              FOR KASE=10    BIVECT( ,13)=MOON  CENTERED AT SUN              RDE31600
00433   317*    C              FOR KASE=17,18    BIVECT( ,13)=EARTHMN  CENTERED AT ICENT      RDE31700
00433   318*    C                                                                              RDE31800
00434   319*          DO 4096 I=1,IARY                                                          RDE31900
00437   320*     4096 BIVECT(I,13)=BIVECT(I,3)-BIVECT(I,L2)                                     RDE32000
00437   321*    C                                                                              RDE32100
00437   322*    C                                                                              RDE32200
00441   323*     4100 DO 4104 I=1,IMAX                                                          RDE32300
00444   324*     4104 TABOUT(I,IBODY)=BIVECT(I,K1)-BIVECT(I,K2)                                 RDE32400
00446   325*     4108 CONTINUE                                                                  RDE32500
00450   326*     5000 IERR=ICOP1                                                                RDE32600
00451   327*          RETURN                                                                    RDE32700
00452   328*          END                                                                       RDE32800

       END OF COMPILATION:        NO  DIAGNOSTICS.


@PRT,T
FURPUR 23A8-01/07-15:29

READE*TPF$  ELEMENT TABLE

C  NAME          VERSION        TYPE          DATE        TIME      SEQ #  SIZE-PRE,TEXT (CYCLE WORD) PSRMODE  LOCATION
   MAIN                         FOR SYMB      07 JAN 73   15:29:27      1              9     5    0    1            1792
   MAIN                         RELOCATABLE   07 JAN 73   15:29:28      2      3       3                           1801
   GETTP4                       FOR SYMB      07 JAN 73   15:29:28      3             62     5    0    1            1813
   GETTP4                       RELOCATABLE   07 JAN 73   15:29:31      4      2      10                           1875
   READE                        FOR SYMB      07 JAN 73   15:29:35      5            176     5    0    1            1887
   READE                        RELOCATABLE   07 JAN 73   15:29:40      6      2      35                           2063
NEXT AVAILABLE LOCATION-                                                                                           2100
```

ASSEMBLER PROCEDURE TABLE EMPTY

COBOL PROCEDURE TABLE EMPTY

FORTRAN PROCEDURE TABLE EMPTY

ENTRY POINT TABLE EMPTY

```
@XGT
MAP   22-5    - 01/07-15:29


ADDRESS LIMITS     001000 012010      040000 051000
STARTING ADDRESS   011035

WORDS DECIMAL        4617 IBANK         4695 DBANK


          SEGMENT MAIN             001000 012010      040000 051000

NSWTC$/FOR                  1    001000 001021
NWEF$/FOR                   1    001022 001204          2    040000 040017
NBDCV$/FOR                  1    001205 001332          2    040020 040062
NFTV$/FOR                   1    001333 001355
NCNVT$/FOR                  1    001356 001575          2    040063 040157
NCLOS$/FOR                  1    001576 001765          2    040160 040210
NBFOO$/FOR                                             2    040211 042412
NOTIN$/FOR                  1    001766 002270          2    042413 042424
NOUT$/FOR                   1    002271 002340          2    042425 042454
NBSBL$/FOR                  1    002341 002375
NRBLK$/FOR                  1    002376 002420
NUPDA$/FOR                  1    002421 002456
NFMT$/FOR                   1    002457 004332          2    042455 042531
NFTCH$/FOR                  1    004333 004646          2    042532 042557
NWBLK$/FOR                  1    004647 004763
NIOER$/FOR                  1    004764 005201          2    042560 042730
UTINFV (COMMON BLOCK)                                       042731 042732
NFCHK$/FOR                  1    005202 006150          2    042734 043106
                            3    UTINFV                 4    043107 043160
NTAB$/FOR                                              2    043161 043335
ERU$
NSTOP$/FOR                  1    006151 006210          2    043336 043351
NOBUF$/FOR                  1    006211 006252          2    043352 043352
NINTR$/FOR                  1    006253 006475          2    043353 043437
NBKSP$/FOR                  1    006476 007154          2    043440 043465
NIER$/FOR                   1    007155 007334          2    043466 043611
NFINP$/FOR                  1    007335 007651          2    043612 043676
NRWND$/FOR                  1    007652 007732          2    043677 043710
NERR$/FOR                   1    007733 010330          2    043711 044111
REC2 (COMMON BLOCK)                                         044112 044142
REC1 (COMMON BLOCK)                                         044143 044172
CETBL9 (COMMON BLOCK)                                       044173 044201
CETBL5 (COMMON BLOCK)                                       044202 044435
CETBL4 (COMMON BLOCK)                                       044436 044665
CETBL3 (COMMON BLOCK)                                       044666 050374
CETBL2 (COMMON BLOCK)                                       050375 050413
CETBL1 (COMMON BLOCK)                                       050414 050423
BLANK$COMMON (COMMON BLOCK)
PEADE                       1    010731 011373          0    050424 050667
```

```
                        3    CETBL1                  2    BLANK*COMMON
                        5    CETBL3                  4    CETBL2
                        7    CETBL5                  6    CETBL4
                                                     8    CETBL9
GETTB4                  1    011374 011634           0    050670 050725
                        3    CETBL2                  2    BLANK*COMMON
                        5    CETBL9                  4    CETBL3
                        7    REC2                    6    REC1
MAIN                    1    011635 012010           0    050726 051000
                        3    CETBL1                  2    BLANK*COMMON
                        5    CETBL4                  4    CETBL2
                        7    REC1                    6    CETBL5
                                                     8    REC2

SYS$*RLIB$. LEVEL 67  01
END OF COLLECTION - TIME 0.945 SECONDS
```

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    .40000000+01     .30000000+01     .40000000+01     .40000000+01     .40000000+01
    .50000000+01     .40000010+01     .60000000+01     .40L00000+01     .70000000+01
    .40000000+01     .80000000+01     .40000000+01     .90000000+01     .40000000+01
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RUNID: DBH011    ACCOUNT: JPCP4          PROJECT: READE

     LOAD G320R  2/1 10          -1 DBH011                  15:29:27


             *** RUN ACCOUNT INFORMATION ***

    ITEM                 AMOUNT              RATE          CHARGE

CPU TIME               12 SEC            $100.10/HR        $    .43
CORE TIME PRODUCT      .25   KWORD HRS   $  4.66/KWORD/HR  $   1.16
NUMBER OF TAPES        1                 $   .38/TAPE      $    .38
PRINTER                84    PAGES       $  .031/PAGE      $   2.61

TOTAL CHARGE FOR THIS RUN                                  $   4.58

          *** MISCELLANEOUS INFORMATION ***
CARDS READ 492      CARDS PUNCHED 0         PAGES PRINTED 84
INITIATION  TIME FOR RUN   15:29:26  ON  JAN  7, 1973
TERMINATION TIME FOR RUN   15:31:12  ON  JAN  7, 1973
AMOUNT REMAINING IN THIS ACCOUNT AS OF 01/06/73     $2773
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XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

D-11597

JULIAN EPHEMERIS DATE = 2440696.5

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			Z		
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.203-09   .277-09   .384-09   .572-09   .866-09   .138-08   .221-08   .368-08V 4Z8-15
.145-01   .612-03   .246-04   .140-05   .812-07   .733-08   .874-09   .382-09V 4W0- 7
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.483+01   .291-01   .166-03   .114-05   .868-09   .110-08   .104-08   .926-09P 5Y0- 7
.115-08   .130-08   .184-08   .234-08   .369-08   .511-08   .864-08   .129-07P 5Y8-15
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.119-08   .158-08   .194-08   .286-08   .394-08   .625-08   .931-08   .155-07P 5W8-15
.764-02   .483-04   .278-06   .265-08   .370-09   .273-09   .312-09   .325-09V 5X0- 7
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.200-09   .274-09   .377-09   .566-09   .851-09   .136-08   .217-08   .363-08V 5Z8-15
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.119-08   .158-08   .194-08   .286-08   .394-08   .625-08   .931-08   .155-07P 6W8-15
.528-02   .132-04   .257-07   .537-09   .361-09   .273-09   .312-09   .325-09V 6X0- 7
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.516-02   .108-04   .308-07   .530-09   .271-09   .275-09   .249-09   .315-09V 6Y0- 7
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.200-09   .274-09   .377-09   .566-09   .851-09   .136-08   .217-08   .363-08V 6Z8-15
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.439-09   .534-09   .818-09   .109-08   .183-08   .267-08   .465-08   .726-08V 6W8-15

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.119-08   .158-08   .194-08   .286-08   .394-08   .625-08   .931-08   .155-07P 7W8-15
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.439-09   .534-09   .818-09   .109-08   .183-08   .267-08   .465-08   .726-08V 7W8-15

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D-11598

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.203-01   .228-02   .258-03   .293-04   .344-05   .416-06   .563-07   .855-08V 2X0- 7
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.439-09   .522-09   .818-09   .109-08   .183-08   .266-08   .465-08   .717-08V 6W8-15

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.439-09   .522-09   .818-09   .109-08   .183-08   .266-08   .465-08   .717-08V 7W8-15

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			1.19231220296648+001	-1.61506190848573-001	7.99932456872045-004
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.100+01	.999-01	.477-02	.348-03	.236-04	.199-05	.152-06	.204-07P 3X0- 7
.348-08	.133-07	.216-07	.320-07	.555-07	.848-07	.156-06	.253-06P 3X8-15
.932+00	.834-01	.442-02	.305-03	.234-04	.182-05	.159-06	.175-07P 3Y0- 7
.950-08	.119-07	.193-07	.302-07	.503-07	.833-07	.141-06	.245-06P 3Y8-15
.404+00	.275-01	.195-02	.132-03	.102-04	.704-06	.692-07	.773-08P 3Z0- 7
.445-08	.599-08	.901-08	.150-07	.229-07	.401-07	.822-07	.114-06P 3Z8-15
.100+01	.999-01	.477-02	.348-03	.236-04	.199-05	.159-06	.204-07P 3W0- 7
.900-08	.133-07	.216-07	.320-07	.555-07	.848-07	.156-06	.253-06P 3W8-15
.175-01	.119-02	.870-04	.590-05	.497-06	.381-07	.547-08	.274-09V 3X0- 7
.376-08	.913-08	.947-08	.107-07	.262-07	.481-07	.798-07	.148-06V 3X8-15
.158-01	.112-02	.782-04	.586-05	.406-06	.399-07	.445-08	.272-09V 3Y0- 7
.384-08	.579-08	.945-08	.152-07	.266-07	.439-07	.793-07	.135-06V 3Y8-15
.687-02	.497-03	.330-04	.254-05	.176-06	.174-07	.198-08	.139-08V 3Z0- 7
.177-08	.706-08	.464-08	.799-08	.131-07	.225-07	.395-07	.679-07V 3Z8-15
.175-01	.119-02	.870-04	.590-05	.497-06	.399-07	.547-08	.274-09V 3W0- 7
.376-08	.913-08	.947-08	.107-07	.266-07	.481-07	.798-07	.148-06V 3W8-15

4 MARS STEP = 4.00

.165+01	.582-01	.245-02	.375-04	.560-05	.323-06	.295-07	.328-08P 4X0- 7
.146-08	.158-08	.195-08	.294-08	.397-08	.620-08	.950-08	.154-07P 4X8-15
.143+01	.552-01	.208-02	.383-04	.453-05	.325-06	.242-07	.345-08P 4Y0- 7
.140-08	.131-08	.185-08	.231-08	.371-08	.518-08	.868-08	.132-07P 4Y8-15
.662+00	.253-01	.955-03	.450-04	.211-05	.149-06	.113-07	.183-08P 4Z0- 7
.722-08	.692-08	.100-08	.124-08	.201-08	.278-08	.471-08	.704-08P 4Z8-15
.165+01	.582-01	.245-02	.383-04	.560-05	.325-06	.295-07	.345-08P 4W0- 7
.146-08	.158-08	.195-08	.294-08	.397-08	.620-08	.950-08	.154-07P 4W8-15

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.145-01   .612-07   .244-04   .140-05   .808-07   .732-08   .836-09   .392-09V 4X0- 7
.444-09   .522-09   .834-09   .111-08   .187-08   .271-08   .476-08   .726-08V 4X8-15
.138-01   .514-07   .246-04   .113-05   .813-07   .606-08   .865-09   .366-09V 4Y0- 7
.366-09   .517-09   .699-09   .107-08   .153-08   .255-08   .405-08   .679-08V 4Y8-15
.633-02   .239-07   .112-04   .528-06   .372-07   .282-08   .428-09   .184-09V 4Z0- 7
.204-09   .267-09   .383-09   .551-09   .881-09   .132-08   .218-08   .353-08V 4Z8-15
.145-01   .512-07   .246-04   .140-05   .813-07   .738-08   .865-09   .382-09V 4W0- 7
.444-09   .522-09   .834-09   .111-08   .187-08   .271-08   .476-08   .726-08V 4W8-15

      5 JUPTER                                STEP =      4.00
.544+01   .306-01   .193-07   .111-05   .103-07   .141-08   .102-08   .115-08P 5X0- 7
.119-08   .156-08   .194-08   .283-08   .394-08   .613-08   .931-08   .154-07P 5X8-15
.484+01   .291-01   .188-07   .113-05   .875-08   .111-08   .104-08   .926-09P 5Y0- 7
.115-08   .129-08   .184-08   .230-08   .359-08   .512-08   .864-08   .129-07P 5Y8-15
.207+01   .125-01   .711-04   .489-06   .386-08   .616-09   .558-09   .514-09P 5Z0- 7
.822-09   .991-09   .994-09   .124-08   .200-08   .278-08   .467-08   .704-08P 5Z8-15
.544+01   .306-01   .193-07   .113-05   .103-07   .141-08   .104-08   .115-08P 5W0- 7
.119-08   .156-08   .194-08   .283-08   .394-08   .619-08   .931-08   .154-07P 5W8-15
.765-02   .482-04   .278-06   .259-08   .376-09   .273-09   .312-09   .323-09V 5X0- 7
.439-08   .521-09   .818-09   .109-08   .183-08   .266-08   .465-08   .717-08V 5X8-15
.727-02   .416-04   .283-06   .216-08   .282-09   .274-09   .248-09   .314-09V 5Y0- 7
.360-09   .516-09   .683-09   .106-08   .155-08   .255-08   .396-08   .679-08V 5Y8-15
.312-02   .178-04   .122-06   .970-09   .158-09   .142-08   .139-09   .162-09V 5Z0- 7
.200-09   .267-09   .377-09   .551-09   .852-09   .132-08   .218-08   .353-08V 5Z8-15
.765-02   .482-04   .283-06   .259-08   .376-09   .274-09   .312-09   .323-09V 5W0- 7
.439-08   .521-09   .818-09   .109-08   .183-08   .266-08   .465-08   .717-08V 5W8-15

      6 SATURN                                STEP =      4.00
.953+01   .311-01   .525-04   .102-06   .219-08   .137-08   .102-08   .115-08P 6X0- 7
.119-08   .156-08   .194-08   .283-08   .394-08   .613-08   .931-08   .154-07P 6X8-15
.928+01   .306-01   .433-04   .123-06   .214-08   .105-08   .104-08   .926-09P 6Y0- 7
.116-08   .129-08   .184-08   .230-08   .359-08   .512-08   .864-08   .129-07P 6Y8-15
.336+01   .801-02   .180-04   .527-07   .112-08   .597-09   .558-09   .514-09P 6Z0- 7
.822-09   .991-09   .994-09   .124-08   .200-08   .278-08   .467-08   .704-08P 6Z8-15
.953+01   .311-01   .525-04   .123-06   .219-08   .137-08   .104-08   .115-08P 6W0- 7
.119-08   .156-08   .194-08   .283-08   .394-08   .613-08   .931-08   .154-07P 6W8-15
.527-02   .131-04   .255-07   .526-09   .362-09   .273-09   .312-09   .323-09V 6X0- 7
.439-08   .521-09   .818-09   .109-08   .183-08   .266-08   .465-08   .717-08V 6X8-15
.515-02   .108-04   .308-07   .562-09   .269-09   .274-09   .248-09   .314-09V 6Y0- 7
.360-09   .516-09   .683-09   .106-08   .155-08   .255-08   .396-08   .679-08V 6Y8-15
.215-02   .449-05   .132-07   .277-09   .154-09   .142-08   .139-09   .162-09V 6Z0- 7
.200-09   .267-09   .377-09   .551-09   .852-09   .132-08   .218-08   .353-08V 6Z8-15
.527-02   .131-04   .308-07   .562-09   .352-09   .274-09   .312-09   .323-09V 6W0- 7
.439-08   .521-09   .818-09   .109-08   .183-08   .266-08   .465-08   .717-08V 6W8-15

      7 URANUS                                STEP =      4.00
.142+02   .156-01   .865-05   .160-07   .191-08   .137-08   .102-08   .115-08P 7X0- 7
.119-08   .156-08   .194-08   .283-08   .394-08   .613-08   .931-08   .154-07P 7X8-15
.177+02   .987-02   .118-04   .120-07   .204-08   .105-08   .104-08   .926-09P 7Y0- 7
.115-08   .129-08   .184-08   .230-08   .369-08   .512-08   .864-08   .129-07P 7Y8-15
.777+01   .408-02   .513-05   .543-08   .105-08   .597-09   .558-09   .514-09P 7Z0- 7
.822-09   .991-09   .994-09   .124-08   .200-08   .273-08   .467-08   .704-08P 7Z8-15
.177+02   .156-01   .118-04   .160-07   .204-08   .137-08   .104-08   .115-08P 7W0- 7
.119-08   .156-08   .194-08   .283-08   .394-08   .613-08   .931-08   .154-07P 7W8-15
```

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.390-02  .216-05  .401-08  .483-09  .362-09  .273-09  .312-09  .323-09V 7X0- 7
.439-09  .521-09  .818-09  .109-08  .183-08  .266-08  .465-08  .717-08V 7X8-15
.242-02  .294-05  .302-08  .512-09  .268-09  .274-09  .248-09  .314-09V 7Y0- 7
.360-09  .516-09  .683-09  .106-08  .155-08  .255-08  .396-08  .679-08V 7Y8-15
.102-02  .128-05  .138-08  .265-09  .154-09  .142-09  .139-09  .162-09V 7Z0- 7
.200-09  .267-09  .377-09  .551-09  .852-09  .132-08  .218-08  .353-08V 7Z8-15
.390-02  .294-05  .401-08  .512-09  .362-09  .274-09  .312-09  .323-09V 7W0- 7
.439-09  .521-09  .818-09  .109-08  .183-08  .266-08  .465-08  .717-08V 7W8-15

     8 NEPTUN                                  STEP =      4.00
.154+02  .126-01  .302-05  .742-08  .101-08  .137-08  .102-08  .115-08P 8X0- 7
.119-08  .156-08  .194-08  .283-08  .394-08  .619-08  .931-08  .154-07P 8X8-15
.280+02  .953-02  .497-05  .692-08  .205-08  .105-08  .104-08  .926-09P 8Y0- 7
.115-08  .129-08  .184-08  .230-08  .369-08  .512-08  .864-08  .129-07P 8Y8-15
.115+02  .241-02  .204-05  .320-08  .106-08  .597-09  .558-09  .514-09P 8Z0- 7
.622-09  .681-09  .994-09  .124-08  .200-08  .278-08  .467-08  .704-08P 8Z8-15
.280+02  .126-01  .497-05  .742-08  .205-08  .137-08  .104-08  .115-08P 8W0- 7
.119-08  .156-08  .194-08  .283-08  .394-08  .619-08  .931-08  .154-07P 8W8-15
.313-02  .757-06  .136-08  .433-09  .362-09  .273-09  .312-09  .323-09V 8X0- 7
.439-09  .521-09  .818-09  .109-08  .183-08  .266-08  .465-08  .717-08V 8X8-15
.163-02  .124-05  .173-08  .513-09  .268-09  .274-09  .248-09  .314-09V 8Y0- 7
.360-09  .516-09  .683-09  .106-08  .155-08  .255-08  .396-08  .679-08V 8Y8-15
.803-03  .511-06  .822-09  .266-09  .154-09  .142-09  .139-09  .162-09V 8Z0- 7
.200-09  .267-09  .377-09  .551-09  .852-09  .132-08  .218-08  .353-08V 8Z8-15
.313-02  .124-05  .136-08  .513-09  .362-09  .274-09  .312-09  .323-09V 8W0- 7
.439-09  .521-09  .818-09  .109-08  .183-08  .266-08  .465-08  .717-08V 8W8-15

     9 PLUTO                                   STEP =      4.00
.248+02  .120-01  .449-05  .707-08  .101-08  .137-08  .102-08  .115-08P 9X0- 7
.119-08  .156-08  .194-08  .283-08  .394-08  .619-08  .931-08  .154-07P 9X8-15
.278+02  .105-01  .483-05  .697-08  .205-08  .105-08  .104-08  .926-09P 9Y0- 7
.115-08  .129-08  .184-08  .230-08  .369-08  .512-08  .864-08  .129-07P 9Y8-15
.567+01  .566-02  .938-06  .952-08  .106-08  .597-09  .558-09  .514-09P 9Z0- 7
.622-09  .681-09  .994-09  .124-08  .200-08  .278-08  .467-08  .704-08P 9Z8-15
.278+02  .120-01  .483-05  .707-08  .205-08  .137-08  .104-08  .115-08P 9W0- 7
.119-08  .156-08  .194-08  .283-08  .394-08  .619-08  .931-08  .154-07P 9W8-15
.301-02  .112-05  .192-08  .483-09  .362-09  .273-09  .312-09  .323-09V 9X0- 7
.439-09  .521-09  .818-09  .109-08  .183-08  .266-08  .465-08  .717-08V 9X8-15
.266-02  .121-05  .173-08  .513-09  .268-09  .274-09  .248-09  .314-09V 9Y0- 7
.360-09  .516-09  .683-09  .106-08  .155-08  .255-08  .396-08  .679-08V 9Y8-15
.141-02  .235-06  .886-09  .266-09  .154-09  .142-09  .139-09  .162-09V 9Z0- 7
.200-09  .267-09  .377-09  .551-09  .852-09  .132-08  .218-08  .353-08V 9Z8-15
.301-02  .121-05  .192-08  .513-09  .362-09  .274-09  .312-09  .323-09V 9W0- 7
.439-09  .521-09  .818-09  .109-08  .183-08  .266-08  .465-08  .717-08V 9W8-15

     10 MOON                                   STEP =      .50
.536+02  .748+01  .914+00  .124+00  .188-01  .381-02  .859-03  .294-03P10X0- 7
.943-04  .398-04  .185-04  .377-05  .552-05  .350-05  .231-05  .181-05P10X8-15
.803+02  .708+01  .366+00  .117+00  .179-01  .336-02  .814-03  .243-03P10Y0- 7
.883-04  .364-04  .172-04  .891-05  .513-05  .314-05  .214-05  .159-05P10Y8-15
.303+02  .355+01  .435+00  .585-01  .900-02  .167-02  .414-03  .122-03P10Z0- 7
.456-04  .181-04  .897-05  .439-05  .269-05  .158-05  .112-05  .773-06P10Z8-15
.536+02  .748+01  .914+00  .124+00  .188-01  .381-02  .859-03  .294-03P10W0- 7
.943-04  .398-04  .185-04  .377-05  .552-05  .350-05  .231-05  .181-05P10W8-15
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.149+02	.183+01	.248+00	.377-01	.720-02	.174-02	.530-03	.190-03V10X0- 7
.807-04	.368-04	.200-04	.110-04	.722-05	.466-05	.364-05	.285-05V10X8-15
.142+02	.174+01	.235+00	.359-01	.675-02	.165-02	.489-03	.181-03V10Y0- 7
.736-04	.356-04	.181-04	.107-04	.647-05	.450-05	.316-05	.285-05V10Y8-15
.712+01	.872+00	.117+00	.181-01	.332-02	.830-03	.243-03	.908-04V10Z0- 7
.373-04	.177-04	.918-05	.526-05	.326-05	.216-05	.160-05	.121-05V10Z8-15
.149+02	.183+01	.248+00	.377-01	.720-02	.174-02	.530-03	.190-03V10W0- 7
.807-04	.368-04	.200-04	.110-04	.722-05	.466-05	.364-05	.285-05V10W8-15

11 NUTAT STEP = .50

.903-04	.537-06	.885-07	.252-07	.708-08	.234-08	.807-09	.433-09P11X0- 7
.533-09	.102-08	.197-08	.383-08	.754-08	.148-07	.289-07	.570-07P11X8-15
.481-04	.203-06	.394-07	.107-07	.313-08	.997-09	.357-09	.201-09P11Y0- 7
.252-09	.449-09	.838-09	.170-08	.334-08	.644-08	.127-07	.247-07P11Y8-15
.000	.000	.000	.000	.000	.000	.000	.000 P11Z0- 7
.000	.000	.000	.000	.000	.000	.000	.000 P11Z8-15
.903-04	.537-06	.885-07	.252-07	.708-08	.234-08	.807-09	.433-09P11W0- 7
.533-09	.102-08	.197-08	.383-08	.754-08	.148-07	.289-07	.570-07P11W8-15
.108-05	.178-06	.505-07	.142-07	.406-08	.166-08	.700-09	.674-09V11X0- 7
.122-08	.225-08	.433-08	.820-08	.157-07	.299-07	.573-07	.109-06V11X8-15
.407-06	.792-07	.215-07	.834-08	.202-08	.702-09	.320-09	.318-09V11Y0- 7
.529-09	.105-08	.192-08	.367-08	.694-08	.133-07	.253-07	.501-07V11Y8-15
.000	.000	.000	.000	.000	.000	.000	.000 V11Z0- 7
.000	.000	.000	.000	.000	.000	.000	.000 V11Z8-15
.108-05	.178-06	.505-07	.142-07	.406-08	.166-08	.700-09	.674-09V11W0- 7
.122-08	.225-08	.433-08	.820-08	.157-07	.299-07	.573-07	.109-06V11W8-15

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