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THE USE OF SHORT ARCS IN ORBIT DETERMINATION

by Hans G. Hertz

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ABSTRACT

At the IAF Congress in Stockholm in 1960, J. Kowalevsky urged that osculating elements of satellite orbits be determined for individual station passages. This implied determinations from short arcs. The present investigation shows that, with the exception of the semi-major axis, the elements of the orbit of Echo I can indeed be determined from arcs with a half-arc length of $1^h.4$ to 4^h to the same accuracy as from conventional 1-day arcs. Several such determinations over an interval as short as 30 hours reveal deviations from gravitational behavior. Using 1-day arcs, such deviations can be readily found only from determinations spanning a longer interval.

CONTENTS

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INTRODUCTION

Most determinations of satellite orbits involve differential corrections based on observations over a period of a day or more. Such differential corrections then lead to the values of osculating elements, integration constants, or other appropriate quantities to be associated with an epoch which is usually near the middle of the period covered by the observations. It is customary to say that the observations of such a period form an arc.

If it were not for the presence of forces not considered in a theory the values of the integration constants of the theory obtained from determinations for different periods or arcs would have to be consistent among themselves and the values of the osculating elements from such determinations would have to be compatible with those indicated by the theory. Any significant deviations would then be ascribed to the effect of forces not included in the theory.

At the International Astronautical Federation Congress in Stockholm in 1960, J. Kowalevsky urged that determinations of osculating elements be made from observations of a single station pass. This means that for one determination the observations over only a short period—say, a few minutes—would be used, and the osculating elements would be determined from short arcs rather than from arcs of one or more days' length.

If this is feasible it would be equally feasible to determine the integration constants from such short arcs. This report deals with some results of determinations of integration constants from short arcs without insisting that the observations be all from one station passage.

The observations used were Baker-Nunn observations.

OBSERVATIONS

The Baker-Nunn observations used were 475 observations of Echo I during the period 1960 August 12 through 1960 August 31. Without using any rigorous procedure this period was divided into elementary intervals which appeared to be separated by gaps in the observations, a process subject to some arbitrariness. There is always an observation at the beginning and end of such an interval. The elementary intervals are given in Table 1. The quantities given are the serial numbers and times of the first and last observation of the interval, the number of observations contained in the interval and the number of duplicate observations; and the length of the interval.

Arcs were then formed by taking one or several consecutive intervals. All possible arcs were formed such that at least 16 observations were included in the arc and that the arc length did not exceed 24 hours. The resulting 563 arcs are listed in Table 2.

The first two columns give the epoch of the middle of the arc, the first column giving the Julian date of the midnight of the day of the middle of the arc and the second column giving the number of seconds from this midnight to the epoch. Column 3 gives the half-arc length in seconds. In columns 4 and 5 the serial numbers of the first and last observations in the arc are shown. The numbers of the observations and of the duplicates are listed in columns 6 and 7. Finally, column 8 contains the serial number of the arc. The same arc was listed under numbers 99 and 100 erroneously. An arc of nearly 12^h half-arc length, with serial number 466 was accidentally excluded from further discussion.

DIFFERENTIAL CORRECTIONS

There are 95 arcs with a half-arc length less than 4 hours (14,400 seconds). For each of these 95 arcs a differential correction was made, based on the observations contained in the arc.

The arc middles are all in the interval August 12-17. This indicates a decrease in the frequency of the observations after August 17 since the observations cover the period from August 12-31. Right ascensions and declinations were given weights consistent with the sums of the squares of the residuals. The unknowns solved for were the constant terms S_1, S_2, S_3, S_4, S_5, and S_6 of the Brouwer expressions (Reference 1) for the osculating elements a, e, I, Ω, ω, and M, with $t = 0$ corresponding to the middle of the arc. Alternately, the S_i may be considered to be the values of the secular portions, using Brouwer's theory, of a, e, I, Ω, ω, and M at the time of the middle of the arc. In the absence of forces not considered by Brouwer, the quantities S_1, S_2, and S_3 should be constant; and S_4, S_5, and S_6 should be linear functions of the time, except for the effects of observational errors.

No quadratic terms in the mean anomalies were introduced. The earth parameters used in these solutions are shown in Table 3. The parameters are the equatorial radius R of the earth and the constants k, k_2, A_{30}, k_4, A_{50}. The last four constants occur in the expression

$$U = \frac{\mu}{r}\left[1 + \frac{k_2}{r^2}\left(1 - 3\sin^2\beta\right) + \frac{A_{30}}{r^3}\left(-\frac{3}{2}\sin\beta + \frac{5}{2}\sin^3\beta\right) + \frac{k_4}{r^4}\left(1 - 10\sin^2\beta + \frac{35}{3}\sin^4\beta\right) + \frac{A_{50}}{r^5}\left(\frac{15}{8}\sin\beta - \frac{35}{4}\sin^3\beta + \frac{63}{8}\sin^5\beta\right)\right] \tag{1}$$

used by Brouwer. The constant k is given by

$$\mu = k^2 \tag{2}$$

Observations with residuals $\cos \delta\Delta\alpha$ and $\Delta\delta$ larger than 0°10 were not used in the solutions.

The values obtained for the s_i are shown in Table 4a. The serial numbers appearing in Table 2 appear in column 15 of Table 4a. Each arc has been assigned an orbit number (shown in column 2). The epoch t is given in column 1, expressed in hours from the arbitrarily chosen point

$$1960 \text{ August } 17,\ 0^h \text{ atomic time (A1)} = \text{J.D. } 2437163.5.$$

The half-arc lengths are given in column 3 and the values of s_1 to s_6 in columns 4 to 9.

Information concerning the accuracy of the representation of the observations of the 95 arcs is also given in Table 4a. The tenth column lists the number of observations used in the solutions. The resulting weights p_α and p_δ in α and δ and the probable errors ϵ_α and ϵ_δ of a residual $\cos \delta\Delta\alpha$ and $\Delta\delta$ respectively are shown in columns 11 to 14. The weights p_α and p_δ have been determined such that their sum is equal to 2.00.

The data in Table 4a show that the rejection limit of 0°10 was too high. A lowering of the limit will probably, if anything, further the case of short arcs. A still better procedure would have been to base the rejection limits on the probable errors of representation.

Table 5a shows, in an arrangement similar to that of Table 4a, the probable errors of the values of the s_i. Those for s_5 and s_6 (the constant terms of ω and M), are rather high due to the small eccentricity of the orbit of Echo I.

In order to compare the results obtained for the short arcs with those obtained from longer arcs, five arcs with half-arc lengths of 12 hours each have been differentially corrected. In view of the greater lengths of these arcs, Brouwer's theory has been modified to include a term $s_{18}\tau^2$, $\tau = 0.01\ t$, in the mean anomaly. The values of $s_i (i = 1, 2, 3, 4, 5, 6, 18)$ are given in Table 4b which, in addition, contains the values of t for the epochs and the orbit numbers 182 to 186 assigned to these arcs. Also given is information on the accuracy of representation of the observations in the five arcs. Table 4b is arranged similarly to Table 4a except that no half-arc lengths and no serial numbers of the arcs are given. Finally, Table 5b contains the probable errors of the elements of Table 4b, the arrangement being similar to that of Table 5a with the half-arc lengths and arc serial numbers being omitted.

The probable errors of Table 5a have been plotted in Figures 1a-f. The plots show the expected increase of the probable errors with decreasing half-arc lengths. Another increase would be expected with increasing half-arc length if the quadratic terms continue to be omitted. This increase, if it materializes, would take place for half-arc lengths in excess of four hours. The graphs imply that it would be reasonable to restrict oneself to arcs with half-arc lengths above $6000^s = 1^h.4$.

ORBITAL BEHAVIOR DERIVED FROM SHORT ARC DATA

While it is not intended to present a detailed analysis of the orbital behavior of Echo I during the 20-day period under discussion some discussion would be appropriate. Of the 95 arcs of

Table 4a whose half-arc lengths are all less than 4 hours, 68 have half-arc lengths of more than $1^h.4$. For these 68 arcs some of the material of Table 4a is repeated in Table 6a. In addition to the values of the S_i the values of the quantities $\Delta\Omega$, $\Delta\omega$, and ΔM, defined by

$$\Delta\Omega = S_4 - (242^\circ.42552 - 0^\circ.12859169 \ t) \tag{3}$$

$$\Delta\omega = S_5 - (18^\circ.22185 + 0^\circ.12340887 \ t) \tag{4}$$

$$\Delta M = S_6 - (87^\circ.18963 + 182^\circ.59437816 \ t) \tag{5}$$

are listed. It will be more convenient to analyze these quantities rather than S_4, S_5, and S_6.

The six quantities S_1, S_2, S_3, $\Delta\Omega$, $\Delta\omega$, and ΔM are plotted versus t in Figures 2a-f. For each of them representations of the form

$$\gamma_0 + \gamma_1 t + \gamma_2 \tau^2, \ \tau = 0.01 \ t \tag{6}$$

were found using all but the first four and last four orbits of Table 6a and by putting $\gamma_2 = 0$. The results are given in Table 7 under solution I. The residuals δa, δe, δI, $\delta\Omega$, $\delta\omega$, and δM are listed in Table 8a and are plotted in Figures 3a-f. The 68 orbits are indicated in Tables 4a, 5a by asterisks. Orbits not used in the solution are indicated in Tables 4a, 5a by underlining the asterisks and in Tables 6a and 8a by the symbol o. The 68 orbits would, however, hardly constitute a proper selection for an orbital study since there are many overlaps and since there is a multiple coverage. The analysis was made because the solutions were available.

The interval covered by the epochs of the 68 arcs is the interval from $t = -47^h.56$ to $t = -16^h.15$. A simple coverage of this interval may be obtained from the eight orbits found in Table 6b for which data correspond to that of Table 6a. These arcs form an acceptable set for studying the orbital behavior of Echo I during the interval referred to above.

The six quantities S_1, S_2, S_3, $\Delta\Omega$, $\Delta\omega$, and ΔM are plotted versus t in Figures 4a-f. Again, representations of the form,

$$\gamma_0 + \gamma_1 t + \gamma_2 \tau^2, \ \tau = 0.01 \ t \ , \tag{7}$$

with $\gamma_2 = 0$, were made for these six quantities. The solution which is based on the first seven orbits of Table 6b appears in Table 7 under solution II. The residuals δa, δe, δI, $\delta\Omega$, $\delta\omega$, and δM are listed in Table 8b and are plotted in Figures 5a-f. The eight orbits of Table 6b are indicated in Tables 4a, 5a by the symbol +; the orbit not being used is indicated by additional underlining. In Tables 6b and 8b this orbit is indicated by the symbol o.

Although according to Table 1 the observations cover the period from August 12-31, their frequencies show such a decrease that no acceptable arc could be formed whose middle occurs after August 17, a few days after launch. In order to gain an idea of the orbital behavior after that date the minimum requirement of 16 observations in an arc has been dropped. A set of 21 arcs could then be found whose epochs cover a period of about 6 days. Of these, 11 did not appear in Tables 4a, 5a. They are listed in corresponding Tables 4c, 5c. The material for the 21 arcs is summarized in Table 6c which corresponds to Table 6a.

The six quantities s_1, s_2, s_3, $\Delta\Omega$, $\Delta\omega$, and ΔM are plotted versus t in Figures 6a-f. For each of these six quantities a representation of the form

$$\gamma_0 + \gamma_1 t + \gamma_2 \tau^2, \quad \tau = 0.01\, t \tag{8}$$

was determined with $\gamma_2 = 0$ in the case of s_1, s_2, s_3 and $\Delta\Omega$. All orbits of Table 6c except 9 orbits marked by the symbol o were used in the solution which appears under Solution III in Table 7. The residuals δa, δe, δI, $\delta\Omega$, $\delta\omega$, and δM are listed in Table 8c and are plotted in Figures 7a-f. In Figures 8a-f the same residuals are shown, only for the orbits used in the solution, thus appearing on a more advantageous scale. The 21 orbits of Table 6c are indicated in Tables 4a, 4c, 5a, 5c by the symbol Δ; the nine orbits not being used are indicated by additional underlining. In Tables 6c and 8c the nine orbits are indicated by the symbol o.

COMPARISON OF RESULTS OBTAINED FROM SHORT AND LONG ARCS

In Tables 9a and 9b comparison data for the results from the short and long arcs are given. The data listed in Table 9a are the mean values of the probable errors of the six $s_i (i = 1, \cdots, 6)$, the minimum and maximum values, the range, and the mean of the minimum and maximum values. In Table 9b similar data are given for the probable errors of an observation in right ascension and declination respectively. The short arc data are those for the 68 arcs of Table 6a whereas the long arc data refer to the five arcs of Table 4b. A larger sample for the long arcs is not available presently due to lack of time and personnel.

The data indicate that in all cases except for s_1 (the semi-major axis), the largest and smallest probable errors occur in the case of the short arcs. The mean of the minimum and maximum values differ considerably from the arithmetic means of the probable errors in the case of the short arcs, but only slightly in case of the long arcs. The mean of the minimum and maximum values are larger in case of the short arcs than in case of the long arcs, but for the arithmetic means the situation is reversed, except for s_1. These facts indicate an asymmetric distribution, a preponderance of the smaller probable errors among the short arcs. To establish this point more firmly a larger number of long arcs should be analyzed.

The fact that these results apply to the probable errors of representation in right ascension and declination is plausible, since shorter arcs can usually be better fitted. The important fact is that they also apply to the probable errors of the s_i, except for s_1. This means that all elements, except for s_1, can be determined from short arcs with the same degree of accuracy as from the longer arcs. The reason may be that the mathematical model used here (Brouwer's theory), becomes less adequate for longer arcs of Echo I due to the existence of non-gravitational influences. The smaller accuracy of the determination of s_1 in shorter arcs, on the other hand, is plausible, since the semi-major axis is practically determined from the mean motion, which in turn is obtained more accurately from longer arcs.

The deviation from gravitational behavior can be recognized from an analysis of the elements of short arcs. The data in Table 7 show that the analyses of the 68 orbits of Table 6a, the 8 orbits of Table 6b, and the 21 orbits of Table 6c, all indicate significant values of rates of changes for the semi-major axis and the eccentricity, which are consistent among each other. The epochs cover a range of 28, 30, and 95 hours respectively. Setting aside the analysis of the 68 orbits which, as was pointed out, is based on an unrealistic sample; we find that it is possible to obtain an indication of deviation from gravitational behavior from short arcs over a period as short as 30 hours. It is not clear that the same could be possible with an analysis of one-day arcs over such a short period. R. Bryant of GSFC has obtained the following values for the rates of change

$$\frac{da}{dt} = -0.000009 \text{ megameters per hour} ,$$

$$\frac{de}{dt} = +0.000024 \text{ per hour}$$

from an analysis of elements covering a range of 42 days. These are in acceptable agreement with the data in Table 7 resulting in additional confidence in the method of short arcs.

The fact that according to Table 7 there are significant values for the values of the linear terms in $\Delta\Omega$, $\Delta\omega$, and ΔM does not necessarily have a physical significance. It primarily means that the linear expressions subtracted from S_4, S_5, and S_6 in the formation of $\Delta\Omega$, $\Delta\omega$, and ΔM have not been completely adjusted such as to generate values of $\Delta\Omega$, $\Delta\omega$, and ΔM free from linear terms in t. We shall not investigate here whether the linear rates of change in S_4, S_5, and S_6 resulting from the analyses of $\Delta\Omega$, $\Delta\omega$, and ΔM are consistent with the gravitational values.

The residuals $\cos\delta\Delta\alpha$ and $\Delta\delta$ versus the mean anomalies for the observations of all 21 orbits of Table 6c are shown in Figures 9a-u and 10a-u. For comparison purposes the residuals for the observations used in deriving the elements of the long arcs of Table 4b, i.e., for orbits 182 to 186, are shown in Figures 11a-e and 12a-e. The minimum and maximum values and the range for M for the observations considered but not necessarily used for each orbit are shown in Table 10a for above 21 orbits and in Table 10b for the five long arcs of Table 4b. The range in M for the long arcs, is, on the average, greater than that for the 21 orbits, which are short arcs. However, the maximum value among the ranges of the short arcs falls only 5° short of the maximum for the long arcs. It seems possible to achieve approximately the same spread around the orbit for short arcs and long arcs alike.

The nine orbits not used in solution III are indicated in Table 10a by asterisks. They were omitted because they showed large residuals. The data in Table 10a indicate that the ranges in M are not small for these orbits compared with those for the orbits retained. The smallest range in Table 10a belongs to an orbit retained whereas the second largest range belongs to an orbit excluded. Further investigations will be necessary to determine whether the rejections are actually justified or not. On the other hand, if for instance, orbit 131 were retained, then there would be a jump of 0.0020 in S_1 between $t = -48^h.48$ and $-46^h.79$ and one of 0.0019 between $t = -46^h.79$ and $-44^h.49$. This jump is according to Table 5a about 15 times the probable error of S_1 for this orbit. R. Bryant has pointed out that there is no physical model which would explain such a jump.

CONCLUSIONS

The results seem to indicate that determinations of elements from short arcs of about $1^h.4$ to 4^h half-arc length need not be less accurate than those from longer arcs and that the determinations from the short arcs, in addition, offer the advantage of finer resolution. The success of the use of short arcs, however, is dependent on the availability of a sufficient number of observations.

ACKNOWLEDGMENTS

The computations on which these results are based were carried out with a differential correction program system and some additional programs. The original package was programmed by Miss Elise R. Fisher of GSFC. This original package was based on the satellite theory by H.G.L. Krause (Reference 2). The services of the IBM Corporation under Dr. K. Deahl were employed to include Brouwer's theory. Additional work was carried out under the supervision of Mr. A. Shapiro of GSFC. Finally the author wishes to thank Messrs. H. Bremer, R. Bryant, R. Danek, and J. Weld of GSFC, and Dr. R. H. Wilson of NASA Headquarters, for help and advice received. Acknowledgment is also due to Smithsonian Astrophysical Observatory for providing the observations prior to publication.

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Table 1

Distribution of Observations in Elementary Intervals.

Ser. No.	Date 1960 Aug.	Time Range	N	Dupl.	Int. Min.	Ser. No.	Date 1960 Aug.	Time Range	N	Dupl.	Int. Min.
1 - 3	12	$10^h55^m - 10^h58^m$	3		3	133-135	15	$09^h45^m - 09^h58^m$	3		13
4 - 4	12	16 54 - 16 54	1		1	136-141	15	10 22 - 10 27	6		5
5 - 7	12	21 04 - 21 5	3		1	142-150	15	12 29 - 12 40	9		11
8 - 13	12	22 39 - 23 12	6		33	151-158	15	14 02 - 14 08	8		6
14 - 16	13	00 44 - 00 53	3		9	159-161	15	14 39 - 14 48	3		9
17 - 19	13	01 18 - 01 19	3		1	162-168	15	16 03 - 16 12	7		9
20 - 21	13	07 12 - 07 22	2		10	169-174	15	22 06 - 22 35	6		29
22 - 25	13	09 19 - 09 29	4		10	175-177	16	00 12 - 00 15	3		3
26 - 28	13	20 46 - 20 46	3		1	178-183	16	01 57 - 02 02	6		5
29 - 31	14	02 41 - 02 45	3		4	184-186	16	02 19 - 02 19	3		1
32 - 34	14	03 03 - 03 03	3		1	187-188	16	04 05 - 04 06	2		1
35 - 39	14	04 49 - 04 53	3	2	4	189-194	16	04 24 - 04 26	6		2
40 - 42	14	08 36 - 08 39	3		3	195-204	16	05 47 - 05 57	10		10
43 - 45	14	09 08 - 09 12	3		4	205-216	16	06 04 - 06 15	12		11
46 - 48	14	10 07 - 10 19	3		12	217-221	16	07 56 - 08 02	5		6
49 - 51	14	14 24 - 14 25	3		1	222-228	16	08 12 - 08 20	7		8
52 - 64	14	22 28 - 22 29	5	8	1	229-247	16	09 22 - 09 38	19		16
65 - 81	15	00 00 - 00 19	17		19	248-250	16	21 44 - 21 45	3		1
82 - 86	15	00 34 - 00 35	5		1	251-253	16	23 49 - 23 51	3		2
87 - 96	15	02 14 - 02 25	10		11	254-257	17	01 31 - 01 42	4		11
97 - 100	15	04 33 - 04 47	4		14	258-260	17	05 47 - 05 55	3		8
101 - 105	15	06 05 - 06 17	5		12	261-266	17	07 29 - 08 01	6		32
106 - 111	15	06 28 - 06 34	6		6	267-269	17	09 12 - 09 12	3		1
112 - 121	15	08 13 - 08 21	10		8	270-272	17	09 57 - 09 57	3		1
122 - 132	15	08 40 - 08 51	11		11	273-274	17	10 13 - 10 15	2		2
			122	10					142	0	

Table 1 (continued)

Ser. No.	Date 1960 Aug.	Time Range	N	Dupl.	Int. Min.
275-276	17	$11^h48^m - 11^h53^m$	2		5
277-279	17	13 56 - 14 03	3		7
280-282	17	21 22 - 21 24	3		2
283-289	18	01 16 - 01 23	2	5	7
290-290	18	03 20 - 03 20	1		1
291-295	18	05 24 - 05 24	1	4	1
296-297	18	05 28 - 05 34	2		6
298-302	18	07 15 - 07 45	5		30
303-303	18	09 18 - 09 18	1		1
304-306	18	09 58 - 09 59	3		1
307-309	18	11 26 - 11 33	3		7
310-312	18	15 02 - 15 06	3		4
313-313	18	15 34 - 15 34	1		1
314-316	18	21 00 - 21 01	3		1
317-319	18	23 06 - 23 08	3		2
320-322	19	00 48 - 00 58	3		10
323-325	19	02 51 - 03 06	3		15
326-328	19	05 01 - 05 09	3		8
329-331	19	06 53 - 06 57	3		4
332-334	19	07 09 - 07 23	3		14
335-337	19	14 42 - 14 43	3		1
338-338	19	20 38 - 20 38	1		1
339-341	20	00 30 - 00 38	3		8
342-344	20	04 45 - 04 48	3		3
			61	9	

Ser. No.	Date 1960 Aug.	Time Range	N	Dupl.	Int. Min.
345-347	20	$06^h49^m - 06^h54^m$	3		5
348-348	20	20 17 - 20 17	1		1
349-351	21	00 28 - 00 30	3		2
352-354	21	02 35 - 02 36	3		1
355-357	21	02 59 - 03 05	3		6
358-360	21	04 39 - 04 42	3		3
361-363	21	08 44 - 08 44	3		1
364-366	21	14 36 - 14 40	3		4
367-367	22	01 47 - 01 47	1		1
368-370	22	04 17 - 04 20	3		3
371-373	22	06 09 - 06 15	3		6
374-374	22	08 06 - 08 06	1		1
375-376	22	08 17 - 08 23	2		6
377-379	22	14 05 - 14 18	3		13
380-382	22	21 38 - 21 40	3		2
383-385	22	23 44 - 23 49	3		5
386-386	23	01 52 - 01 52	1		1
387-389	23	02 14 - 02 20	3		6
390-392	23	03 56 - 03 57	3		1
393-395	23	07 48 - 07 53	3		5
396-398	23	11 40 - 11 52	3		12
399-401	23	13 44 - 13 58	3		14
402-403	23	21 17 - 21 17	2		1
404-406	23	23 22 - 23 24	3		2
			62	0	

Table 1 (continued)

Ser. No.	Date 1960 Aug.	Time Range	N	Dupl.	Int. Min.
407-409	24	01^h28 - 01^h35^m	3		7
410-412	24	03 30 - 03 35	3		5
413-415	24	09 33 - 09 38	3		5
416-418	24	13 29 - 13 37	3		8
419-421	24	19 41 - 19 48	3		7
422-423	24	20 55 - 20 55	2		1
424-426	24	23 01 - 23 02	3		1
427-427	25	01 06 - 01 06	1		1
428-430	25	20 32 - 20 37	3		5
431-433	25	22 38 - 22 40	3		2
434-435	26	03 09 - 03 11	2		2
436-438	26	04 40 - 04 40	3		1
439-441	26	14 49 - 14 52	3		3
442-442	26	20 11 - 20 11	1		1
443-443	27	02 14 - 02 14	1		1
444-446	27	21 54 - 21 55	3		1
447-449	27	23 59 - 23 59	3		1
450-452	28	01 44 - 01 51	3		7
453-454	28	23 35 - 23 38	2		3
455-457	29	01 18 - 01 24	3		6
458-460	29	19 50 - 20 05	3		15
461-463	29	21 09 - 21 14	3		5
464-464	29	23 16 - 23 16	1		1
465-467	30	00 59 - 01 03	3		4
468-469	30	01 47 - 01 51	2		4
470-472	30	22 54 - 22 55	3		1
473-475	31	20 26 - 20 27	3		1
			69	0	

Table 2

Arcs with Half-arc Lengths of less than 12^h.

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437158.50	64440^s	25140^s	1	16	16	0	64
2437158.50	65220	25920	1	19	19	0	105
2437158.50	75990	15150	4	19	16	0	65
2437158.50	76110	36810	1	21	21	0	182
2437158.50	79920	40620	1	25	25	0	264
2437159.50	480	26040	4	21	17	0	106
2437159.50	4290	29850	4	25	22	0	183
2437159.50	7980	18540	5	21	17	0	66
2437159.30	11790	22350	5	25	21	0	107
2437159.50	14640	19500	8	25	18	0	67
2437159.50	32100	42660	5	28	24	0	184
2437159.50	34950	39810	8	28	21	0	108
2437159.50	64950	39030	20	39	18	2	109
2437159.50	68760	35220	22	39	16	2	68
2437159.50	75540	42000	22	42	19	2	110
2437159.50	76530	42990	22	45	22	2	185
2437160.50	10740	22380	26	45	18	2	111
2437160.50	12750	24390	26	48	21	2	186
2437160.50	23400	13740	29	48	18	2	112
2437160.50	30780	21120	29	51	21	2	187
2437160.50	31440	20460	32	51	18	2	113
2437160.50	45300	35640	29	64	26	10	265
2437160.50	45960	34980	32	64	23	10	188
2437160.50	48600	38940	29	81	43	10	333
2437160.50	49080	39420	29	86	48	10	390
2437160.50	49140	31800	35	64	20	10	114
2437160.50	49260	38280	32	81	40	10	266
2437160.50	49740	38760	32	86	45	10	334
2437160.50	52380	42720	29	96	58	10	438
2437160.50	52440	35100	35	81	37	10	189
2437160.50	52920	35580	35	86	42	10	267
2437160.50	53040	42060	32	96	55	10	391
2437160.50	55950	24990	40	64	17	0	69
2437160.50	56220	38880	35	96	52	10	335
2437160.50	59250	28290	40	81	34	8	115
2437160.50	59730	28770	40	86	39	8	190
2437160.50	60210	27330	43	81	31	8	70
2437160.50	60480	43140	35	100	56	10	392
2437160.50	60690	27810	43	86	36	8	116
2437160.50	61980	25560	46	81	28	8	35

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437160.50	62460^s	26040^s	46	86	35	8	71
2437160.50	63030	32070	40	96	49	8	268
2437160.50	63990	31110	43	96	46	8	191
2437160.50	65760	29340	46	96	43	8	117
2437160.50	67290	36330	40	100	53	8	336
2437160.50	68250	35370	43	100	50	8	269
2437160.50	69690	17850	49	81	25	8	13
2437160.50	69990	39030	40	105	58	8	393
2437160.50	70020	33600	46	100	47	8	192
2437160.50	70170	18330	49	86	30	8	36
2437160.50	70500	39540	40	111	64	8	439
2437160.50	70950	38070	43	105	55	8	337
2437160.50	71460	38580	43	111	61	8	394
2437160.50	72720	36300	46	105	52	8	270
2437160.50	73230	36810	46	111	58	8	338
2437160.50	73470	21630	49	96	40	8	72
2437160.50	73710	42750	40	121	74	8	477
2437160.50	74670	41790	43	121	71	8	440
2437160.50	75570	42690	43	132	82	8	478
2437160.50	76440	40020	46	121	68	8	395
2437160.50	77340	40920	46	132	79	8	441
2437160.50	77730	25890	49	100	44	8	118
2437160.50	79350	42930	46	135	82	8	479
2437160.50	80430	28590	49	105	49	8	193
2437160.50	80940	29100	49	111	55	8	271
2437160.50	84150	32310	49	121	65	8	339
2437160.50	84210	3330	52	81	22	8	3
2437160.50	84690	3810	52	86	27	8	14
2437160.50	85050	33210	49	132	76	8	396
2437161.50	570	570	65	81	17	0	1
2437161.50	660	35220	49	135	79	8	442
2437161.50	1050	1050	65	86	22	0	4
2437161.50	1530	36090	49	141	85	8	480
2437161.50	1590	7110	52	96	37	8	37
2437161.50	4350	4350	65	96	32	0	15
2437161.50	5520	40080	49	150	94	8	507
2437161.50	5850	11370	52	100	41	8	73
2437161.50	8160	42720	49	158	102	8	525
2437161.50	8550	14070	52	105	46	8	119
2437161.50	8610	8610	65	100	36	0	38
2437161.50	9060	14580	52	111	52	8	194
2437161.50	9630	7590	82	100	19	0	16

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437161.50	11310^s	11310^s	65	105	41	0	74
2437161.50	11820	11820	65	111	47	0	120
2437161.50	12270	17790	52	121	62	8	272
2437161.50	12330	10290	82	105	24	0	39
2437161.50	12840	10800	82	111	30	0	75
2437161.50	13170	18690	52	132	73	8	340
2437161.50	15030	15030	65	121	57	0	195
2437161.50	15180	20700	52	135	76	8	397
2437161.50	15330	7290	87	105	19	0	17
2437161.50	15840	7800	87	111	25	0	40
2437161.50	15930	15930	65	132	68	0	273
2437161.50	16050	14010	82	121	40	0	121
2437161.50	16050	21570	52	141	82	8	443
2437161.50	16950	14910	82	132	41	0	196
2437161.50	17940	17940	65	135	71	0	341
2437161.50	18810	18810	65	141	77	0	398
2437161.50	18960	16920	82	135	54	0	274
2437161.50	19050	11010	87	121	35	0	76
2437161.50	19830	17790	82	141	60	0	342
2437161.50	19950	11910	87	132	46	0	122
2437161.50	20040	25560	52	150	91	8	481
2437161.50	21960	13920	87	135	49	0	197
2437161.50	22680	28200	52	158	99	8	508
2437161.50	22800	22800	65	150	86	0	444
2437161.50	22830	14790	87	141	55	0	275
2437161.50	23220	6840	97	121	25	0	41
2437161.50	23820	21780	82	150	69	0	399
2437161.50	23880	29400	52	161	102	8	526
2437161.50	24120	7740	97	132	36	0	77
2437161.50	25440	25440	65	158	94	0	482
2437161.50	25980	4080	101	121	21	0	18
2437161.50	26130	9750	97	135	39	0	123
2437161.50	26400	31920	52	168	109	8	539
2437161.50	26460	24420	82	158	77	0	445
2437161.50	26640	26640	65	161	97	0	509
2437161.50	26670	3390	106	121	16	0	5
2437161.50	26820	18780	87	150	64	0	343
2437161.50	26880	4980	101	132	32	0	42
2437161.50	27000	10620	97	141	45	0	198
2437161.50	27570	4290	106	132	27	0	19
2437161.50	27660	25620	82	161	70	0	483
2437161.50	28890	6990	101	135	35	0	78

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	Ser. no. of obs. End	No. of Obs.	No. of Dupl.	Ser. No.
2437161.50	29160^s	29160^s	65	168	104	0	527
2437161.50	29460	21420	87	158	72	0	400
2437161.50	29580	6300	106	135	30	0	43
2437161.50	29760	7860	101	141	41	0	124
2437161.50	30180	28140	82	168	87	0	510
2437161.50	30450	7170	106	141	36	0	79
2437161.50	30660	22620	87	161	75	0	446
2437161.50	30720	1140	112	132	21	0	6
2437161.50	30990	14610	97	150	54	0	276
2437161.50	32730	3150	112	135	24	0	20
2437161.50	33180	25140	87	168	82	0	484
2437161.50	33600	4020	112	141	30	0	44
2437161.50	33630	17250	97	158	62	0	344
2437161.50	33750	11850	101	150	50	0	199
2437161.50	34410	3210	122	141	20	0	21
2437161.50	34440	11160	106	150	45	0	125
2437161.50	34830	18450	97	161	65	0	401
2437161.50	36390	14490	101	158	58	0	277
2437161.50	37080	13800	106	158	53	0	200
2437161.50	37350	20970	97	168	72	0	447
2437161.50	37590	8010	112	150	39	0	80
2437161.50	37590	15690	101	161	61	0	345
2437161.50	38280	15000	106	161	56	0	278
2437161.50	38400	7200	122	150	29	0	45
2437161.50	40110	18210	101	168	68	0	402
2437161.50	40230	10650	112	158	47	0	126
2437161.50	40350	5250	133	150	18	0	22
2437161.50	40650	40650	65	174	110	0	540
2437161.50	40800	17520	106	168	63	0	346
2437161.50	41040	9840	122	158	37	0	81
2437161.50	41430	11850	112	161	50	0	201
2437161.50	41670	39630	82	174	93	0	528
2437161.50	42240	11040	122	161	40	0	127
2437161.50	42990	7890	133	158	26	0	46
2437161.50	43950	14370	112	168	57	0	279
2437161.50	44100	6780	136	158	23	0	23
2437161.50	44190	9090	133	161	29	0	82
2437161.50	44670	36630	87	174	88	0	511
2437161.50	44670	42630	82	177	96	0	541
2437161.50	44760	13560	122	168	47	0	202
2437161.50	45300	7980	136	161	26	0	47
2437161.50	46710	11610	133	168	36	0	128
2437161.50	47670	39630	87	177	91	0	529

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	Ser. no. of obs. End	No. of Obs.	No. of Dupl.	Ser. No.
2437161.50	47820^s	10500^s	136	168	33	0	83
2437161.50	47910	2970	142	158	17	0	7
2437161.50	48840	32460	97	174	78	0	485
2437161.50	49110	4170	142	161	20	0	24
2437161.50	50880	42840	87	183	97	0	542
2437161.50	51600	29700	101	174	74	0	448
2437161.50	51630	6690	142	168	27	0	48
2437161.50	51840	35460	97	177	81	0	512
2437161.50	52290	29010	106	174	69	0	403
2437161.50	54420	3900	151	168	18	0	25
2437161.50	54600	32700	101	177	77	0	486
2437161.50	55050	38670	97	183	87	0	530
2437161.50	55290	32010	106	177	72	0	449
2437161.50	55440	25860	112	174	63	0	347
2437161.50	55560	39180	97	186	90	0	543
2437161.50	56250	25050	122	174	53	0	280
2437161.50	57810	35910	101	183	83	0	513
2437161.50	58200	23100	133	174	42	0	203
2437161.50	58320	36420	101	186	86	0	531
2437161.50	58440	28860	112	177	66	0	404
2437161.50	58500	35220	106	183	78	0	487
2437161.50	58770	42390	97	188	92	0	551
2437161.50	59010	35730	106	186	81	0	514
2437161.50	59250	28050	122	177	56	0	348
2437161.50	59310	21990	136	174	39	0	129
2437161.50	59370	42990	97	194	98	0	558
2437161.50	61200	26100	133	177	45	0	281
2437161.50	61530	39630	101	188	88	0	544
2437161.50	61650	32070	112	183	72	0	450
2437161.50	62130	40230	101	194	94	0	552
2437161.50	62160	32580	112	186	75	0	488
2437161.50	62220	38940	106	188	83	0	532
2437161.50	62310	24990	136	177	42	0	204
2437161.50	62460	31260	122	183	62	0	405
2437161.50	62820	39540	106	194	89	0	545
2437161.50	62970	31770	122	186	65	0	451
2437161.50	63120	18180	142	174	33	0	84
2437161.50	64410	29310	133	183	51	0	349
2437161.50	64860	42960	101	204	104	0	559
2437161.50	64920	29820	133	186	54	0	406
2437161.50	65370	35790	112	188	77	0	515
2437161.50	65520	28200	136	183	48	0	282
2437161.50	65550	42270	106	204	99	0	553

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437161.50	65910^s	15390^s	151	174	24	0	49
2437161.50	65970	36390	112	194	83	0	533
2437161.50	66030	28710	136	186	51	0	350
2437161.50	66090	42810	106	216	111	0	560
2437161.50	66120	21180	142	177	36	0	130
2437161.50	66180	34980	122	188	67	0	489
2437161.50	66780	35580	122	194	73	0	516
2437161.50	67020	14280	159	174	16	0	26
2437161.50	68130	33030	133	188	56	0	452
2437161.50	68700	39120	112	204	93	0	546
2437161.50	68730	33630	133	194	62	0	490
2437161.50	68910	18390	151	177	27	0	85
2437161.50	69240	31920	136	188	53	0	407
2437161.50	69240	39660	112	216	105	0	554
2437161.50	69330	24390	142	183	42	0	205
2437161.50	69510	38310	122	204	83	0	534
2437161.50	69840	24900	142	186	45	0	283
2437161.50	69840	32520	136	194	59	0	453
2437161.50	70020	17280	159	177	19	0	50
2437161.50	70050	38850	122	216	95	0	547
2437161.50	71460	36360	133	204	72	0	517
2437161.50	72000	36900	133	216	84	0	535
2437161.50	72120	21600	151	183	33	0	131
2437161.50	72150	14370	162	221	60	0	411
2437161.50	72450	42870	112	221	110	0	561
2437161.50	72540	14760	162	177	16	0	27
2437161.50	72570	35250	136	204	69	0	491
2437161.50	72630	22110	151	186	36	0	206
2437161.50	73050	28110	142	188	47	0	351
2437161.50	73110	35790	136	216	81	0	518
2437161.50	73230	20490	159	183	25	0	86
2437161.50	73260	42060	122	221	100	0	555
2437161.50	73650	28710	142	194	53	0	408
2437161.50	73740	21000	159	186	28	0	132
2437161.50	73800	42600	122	228	107	0	562
2437161.50	75210	40110	133	221	89	0	548
2437161.50	75750	17970	162	183	22	0	51
2437161.50	75750	40650	133	228	96	0	556
2437161.50	75840	25320	151	188	38	0	284
2437161.50	76260	18480	162	186	25	0	87
2437161.50	76320	39000	136	221	86	0	536
2437161.50	76380	31440	142	204	63	0	454

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437161.50	76440^s	25920^s	151	194	44	0	352
2437161.50	76860	39540	136	228	93	0	549
2437161.50	76920	31980	142	216	75	0	492
2437161.50	76950	24210	159	188	30	0	207
2437161.50	77550	24810	159	194	36	0	285
2437161.50	78090	42990	133	247	115	0	563
2437161.50	79170	28650	151	204	54	0	409
2437161.50	79200	41880	136	247	112	0	557
2437161.50	79470	21690	162	188	27	0	133
2437161.50	79710	29190	151	216	66	0	455
2437161.50	80070	22290	162	194	33	0	208
2437161.50	80130	35190	142	221	80	0	519
2437161.50	80280	27540	159	204	46	0	353
2437161.50	80670	35730	142	228	87	0	537
2437161.50	80820	28080	159	216	58	0	410
2437161.50	82800	25020	162	204	43	0	286
2437161.50	82920	32400	151	221	71	0	493
2437161.50	83010	38070	142	247	106	0	550
2437161.50	83340	25560	162	216	55	0	354
2437161.50	83460	32940	151	228	78	0	520
2437161.50	84030	31290	159	221	63	0	456
2437161.50	84570	31830	159	228	70	0	494
2437161.50	85800	35280	151	247	97	0	538
2437162.50	510	34170	159	247	89	0	521
2437162.50	690	29310	162	228	67	0	457
2437162.50	750	7590	169	186	18	0	52
2437162.50	3030	31650	162	247	86	0	495
2437162.50	3960	10800	169	188	20	0	88
2437162.50	4560	11400	169	194	26	0	134
2437162.50	7290	14130	169	204	36	0	209
2437162.50	7830	14670	169	216	48	0	287
2437162.50	8340	7620	175	194	20	0	89
2437162.50	11040	17880	169	221	53	0	355
2437162.50	11070	10350	175	204	30	0	135
2437162.50	11490	4470	178	194	17	0	53
2437162.50	11580	18420	169	228	60	0	412
2437162.50	11610	10890	175	216	42	0	210
2437162.50	13920	20760	169	247	79	0	458
2437162.50	14220	7200	178	204	27	0	90
2437162.50	14760	7740	178	216	39	0	136
2437162.50	14820	14100	175	221	47	0	288
2437162.50	14880	6540	184	204	21	0	54
2437162.50	15360	14640	175	228	54	0	356

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437162.50	15420^s	7080^s	184	216	33	0	91
2437162.50	17700	16980	175	247	73	0	413
2437162.50	17970	10950	178	221	44	0	211
2437162.50	18060	3360	187	204	18	0	28
2437162.50	18510	11490	178	228	51	0	289
2437162.50	18600	3900	187	216	30	0	55
2437162.50	18630	2790	189	204	16	0	8
2437162.50	18630	10290	184	221	38	0	137
2437162.50	19170	3330	189	216	28	0	29
2437162.50	19170	10830	184	228	45	0	212
2437162.50	20850	13830	178	247	70	0	357
2437162.50	21510	13170	184	247	64	0	290
2437162.50	21660	840	195	216	22	0	9
2437162.50	21810	7110	187	221	35	0	92
2437162.50	22350	7650	187	228	42	0	138
2437162.50	22380	6540	189	221	33	0	56
2437162.50	22920	7080	189	228	40	0	93
2437162.50	24690	9990	187	247	61	0	213
2437162.50	24870	4050	195	221	27	0	30
2437162.50	25260	9420	189	247	59	0	139
2437162.50	25380	3540	205	221	17	0	10
2437162.50	25410	4590	195	228	34	0	57
2437162.50	25920	4080	205	228	24	0	31
2437162.50	27750	6930	195	247	53	0	94
2437162.50	28260	6420	205	247	43	0	58
2437162.50	31620	3060	217	247	31	0	32
2437162.50	32100	2580	222	247	26	0	11
2437162.50	34200	480	229	247	19	0	2
2437162.50	35730	42570	169	250	82	0	496
2437162.50	39510	38790	175	250	76	0	459
2437162.50	42660	35640	178	250	73	0	414
2437162.50	43290	42570	175	253	79	0	497
2437162.50	43320	34980	184	250	67	0	358
2437162.50	46500	31800	187	250	64	0	291
2437162.50	47070	31230	189	250	62	0	214
2437162.50	47100	38760	184	253	70	0	415
2437162.50	49560	28740	195	250	56	0	140
2437162.50	49770	42750	178	257	80	0	498
2437162.50	50070	28230	205	250	46	0	95
2437162.50	50280	35580	187	253	67	0	359
2437162.50	50430	42090	184	257	74	0	461
2437162.50	50850	35010	189	253	65	0	292
2437162.50	53340	32520	195	253	59	0	215

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437162.50	53430^s	24870^s	217	250	34	0	59
2437162.50	53610	38910	187	257	71	0	416
2437162.50	53850	32010	205	253	49	0	141
2437162.50	53910	24390	222	250	29	0	33
2437162.50	54180	38340	189	257	69	0	360
2437162.50	56010	22290	229	250	22	0	12
2437162.50	56670	35850	195	257	63	0	293
2437162.50	57180	35340	205	257	53	0	216
2437162.50	57210	28650	217	253	37	0	96
2437162.50	57690	28170	222	253	32	0	60
2437162.50	59790	26070	229	253	25	0	34
2437162.50	60540	31980	217	257	41	0	142
2437162.50	61020	31500	222	257	36	0	97
2437162.50	63120	29400	229	257	29	0	61
2437162.50	64770	42930	205	260	56	0	294
2437162.50	68130	39570	217	260	44	0	217
2437162.50	68610	39090	222	260	39	0	143
2437162.50	70710	36990	229	260	32	0	98
2437162.50	72390	42870	222	266	45	0	218
2437162.50	74490	40770	229	266	38	0	144
2437162.50	76620	42900	229	269	41	0	219
2437163.50	3240	82620	178	253	76	0	460
2437163.50	10350	18510	248	266	19	0	99
2437163.50	10350	18510	248	266	19	0	100
2437163.50	12480	20640	248	269	22	0	145
2437163.50	13830	21990	248	272	25	0	220
2437163.50	14100	14760	251	266	16	0	62
2437163.50	14370	22530	248	274	27	0	295
2437163.50	16230	16890	251	269	19	0	101
2437163.50	17310	25470	248	276	29	0	361
2437163.50	17580	18240	251	272	22	0	146
2437163.50	18120	18780	251	274	24	0	221
2437163.50	19290	13830	254	269	16	0	63
2437163.50	20640	15180	254	272	19	0	102
2437163.50	21060	21720	251	276	26	0	296
2437163.50	21180	15720	254	274	21	0	147
2437163.50	21210	29370	248	279	32	0	417
2437163.50	24120	18660	254	276	23	0	222
2437163.50	24960	25620	251	279	29	0	362
2437163.50	28020	22560	254	279	26	0	297

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437163.50	28860^s	8040^s	258	274	17	0	103
2437163.50	31800	10980	258	276	19	0	148
2437163.50	34440	42600	248	282	35	0	462
2437163.50	34860	7920	261	276	16	0	104
2437163.50	35700	14880	258	279	22	0	223
2437163.50	38190	38850	251	282	32	0	418
2437163.50	38760	11820	261	279	19	0	149
2437163.50	41250	35790	254	282	29	0	363
2437163.50	48420	42960	254	289	31	5	419
2437163.50	49530	28710	258	282	25	0	298
2437163.50	51990	25050	261	282	22	0	224
2437163.50	55080	21960	267	282	16	0	150
2437163.50	56100	35280	258	289	27	5	364
2437163.50	59160	32220	261	289	24	5	299
2437163.50	59610	38790	258	290	28	5	420
2437163.50	62250	29130	267	289	18	5	225
2437163.50	62670	35730	261	290	25	5	365
2437163.50	63330	42510	258	295	29	9	463
2437163.50	63630	42810	258	297	31	0	499
2437163.50	65760	32640	267	290	19	5	300
2437163.50	66390	39450	261	295	26	9	421
2437163.50	66690	39750	261	297	28	9	464
2437163.50	67110	31290	270	290	16	5	226
2437163.50	69480	36360	267	295	20	9	366
2437163.50	69780	36660	267	297	22	9	422
2437163.50	70830	35010	270	295	17	9	301
2437163.50	71130	35310	270	297	19	9	367
2437163.50	71610	34830	273	297	16	9	302
2437163.50	73710	40590	267	302	27	9	465
2437163.50	75060	39240	270	302	24	9	423
2437163.50	75540	38760	273	302	21	9	368
2437163.50	78330	41550	273	303	22	9	424
2437163.50	78390	35910	275	302	19	9	303
2437163.50	79560	42780	273	306	25	9	467
2437163.50	81180	38700	275	303	20	9	369
2437163.50	82230	32070	277	302	17	9	227
2437163.50	82410	39930	275	306	23	9	425
2437163.50	85020	34860	277	303	18	9	304
2437163.50	85230	42750	275	309	26	9	468
2437163.50	86250	36090	277	306	21	9	370

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437164.50	2670^s	38910^s	277	309	24	9	426
2437164.50	13230	22710	280	306	18	9	305
2437164.50	16050	25530	280	309	21	9	371
2437164.50	22440	31920	280	312	24	9	427
2437164.50	23070	18510	283	309	18	9	306
2437164.50	23280	32760	280	313	25	9	469
2437164.50	26790	14790	290	309	16	4	228
2437164.50	29460	24900	283	312	21	9	372
2437164.50	30300	25740	283	313	22	9	428
2437164.50	33090	42570	280	316	28	9	500
2437164.50	33180	21180	290	312	19	4	307
2437164.50	34020	22020	290	313	20	4	373
2437164.50	36900	17460	291	312	18	4	229
2437164.50	37020	17340	296	312	17	0	151
2437164.50	37740	18300	291	313	19	4	308
2437164.50	37860	18180	296	313	18	0	230
2437164.50	40110	35550	283	316	25	9	470
2437164.50	41070	14970	298	313	16	0	152
2437164.50	43830	31830	290	316	23	4	429
2437164.50	43920	39360	283	319	28	9	501
2437164.50	47220	42660	283	322	31	9	522
2437164.50	47550	28110	291	316	22	4	374
2437164.50	47640	35640	290	319	26	4	471
2437164.50	47670	27990	296	316	21	0	309
2437164.50	50880	24780	298	316	19	0	231
2437164.50	50940	38940	290	322	29	4	502
2437164.50	51360	31920	291	319	25	4	430
2437164.50	51480	31800	296	319	24	0	375
2437164.50	54660	35220	291	322	28	4	472
2437164.50	54690	28590	298	319	22	0	310
2437164.50	54780	35100	296	322	27	0	431
2437164.50	54780	42780	290	325	32	4	523
2437164.50	57990	31890	298	322	25	0	376
2437164.50	58380	24900	303	319	17	0	232
2437164.50	58500	39060	291	325	31	4	503
2437164.50	58620	38940	296	325	30	0	473
2437164.50	59580	23700	304	319	16	0	153
2437164.50	61680	28200	303	322	20	0	311
2437164.50	61830	35730	298	325	28	0	432
2437164.50	62190	42750	291	328	34	4	524

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437164.50	62310^s	42630^s	296	328	33	0	504
2437164.50	62880	27000	304	322	19	0	233
2437164.50	65520	24360	307	322	16	0	154
2437164.50	65520	32040	303	325	23	0	377
2437164.50	65520	39420	298	328	31	0	474
2437164.50	66720	30840	304	325	22	0	312
2437164.50	68760	42660	298	331	34	0	505
2437164.50	69210	35730	303	328	26	0	433
2437164.50	69360	28200	307	325	19	0	234
2437164.50	70410	34530	304	328	25	0	378
2437164.50	72450	38970	303	331	29	0	475
2437164.50	73050	31890	307	328	22	0	313
2437164.50	73230	39750	303	334	32	0	506
2437164.50	73650	37770	304	331	28	0	434
2437164.50	74430	38550	304	334	31	0	476
2437164.50	75840	21720	310	325	16	0	155
2437164.50	76290	35130	307	331	25	0	379
2437164.50	77070	35910	307	334	28	0	435
2437164.50	79530	25410	310	328	19	0	235
2437164.50	80490	24450	313	328	16	0	156
2437164.50	82770	28650	310	331	22	0	314
2437164.50	83550	29430	310	334	25	0	380
2437164.50	83730	27690	313	331	19	0	236
2437164.50	84510	28470	313	334	22	0	315
2437165.50	7110	17910	314	331	18	0	157
2437165.50	7890	18690	314	334	21	0	237
2437165.50	10350	42630	310	337	28	0	436
2437165.50	11310	41670	313	337	25	0	381
2437165.50	11670	14910	317	335	18	0	158
2437165.50	21090	31890	314	337	24	0	316
2437165.50	24870	28110	317	337	21	0	238
2437165.50	27930	25050	320	337	18	0	159
2437165.50	31740	42540	314	338	25	0	382
2437165.50	35520	38760	317	338	22	0	317
2437165.50	38580	35700	320	338	19	0	239
2437165.50	42270	32010	323	338	16	0	160
2437165.50	45780	42900	320	341	22	0	318
2437165.50	49470	39210	323	341	19	0	240
2437165.50	53370	35310	326	342	16	0	161
2437165.50	60870	42810	326	344	19	0	241
2437165.50	64230	39450	329	344	16	0	162

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437165.50	68490^s	42750^s	332	347	16	0	163
2437166.50	57300	40200	342	357	16	0	164
2437166.50	60210	43110	342	360	19	0	242
2437166.50	63930	39390	345	360	16	0	165
2437167.50	9030	22410	348	363	16	0	166
2437167.50	19710	33090	348	366	19	0	243
2437167.50	27240	25560	349	366	18	0	167
2437167.50	51060	41760	352	367	16	0	168
2437167.50	74010	42570	361	376	16	0	244
2437168.50	8820	42660	364	379	16	0	245
2437168.50	42210	35790	367	382	16	0	246
2437168.50	46080	39660	367	385	19	0	319
2437168.50	50580	35160	368	385	18	0	247
2437168.50	54270	38850	368	386	19	0	320
2437168.50	55110	39690	368	389	22	0	383
2437168.50	57630	35490	371	386	16	0	248
2437168.50	58020	42600	368	392	25	0	437
2437168.50	58470	36330	371	389	19	0	321
2437168.50	61380	39240	371	392	22	0	384
2437168.50	61980	32820	374	389	16	0	249
2437168.50	64890	35730	374	392	19	0	322
2437168.50	65220	35400	375	392	18	0	250
2437168.50	71970	42810	374	395	22	0	385
2437168.50	72300	42480	375	395	21	0	323
2437168.50	75660	24960	377	392	16	0	169
2437168.50	82740	32040	377	395	19	0	251
2437169.50	3510	39210	377	398	22	0	324
2437169.50	7290	42990	377	401	25	0	386
2437169.50	9930	18450	380	395	16	0	170
2437169.50	17100	25620	380	398	19	0	252
2437169.50	20880	21840	383	398	16	0	171
2437169.50	20880	29400	380	401	22	0	325
2437169.50	24660	25620	383	401	19	0	253
2437169.50	28500	21780	386	401	16	0	172
2437169.50	34050	42570	380	403	24	0	387
2437169.50	37830	38790	383	403	21	0	326
2437169.50	41640	42600	383	406	24	0	388
2437169.50	41670	34950	386	403	18	0	254
2437169.50	42330	34290	387	403	17	0	173
2437169.50	45480	38760	386	406	21	0	327

Table 2 (continued)

JD	Seconds past 0^h for middle of arc	Half-arc length	Ser. no. of obs. Beg.	End	No. of Obs.	Dupl.	Ser. No.
2437169.50	46140^s	38100^s	387	406	20	0	255
2437169.50	49200	35040	390	406	17	0	174
2437169.50	49410	42690	386	409	24	0	389
2437169.50	50070	42030	387	409	23	0	328
2437169.50	53130	38970	390	409	20	0	256
2437169.50	56730	42570	390	412	23	0	329
2437169.50	60090	32010	393	409	17	0	175
2437169.50	63690	35610	393	412	20	0	257
2437169.50	70650	28650	396	412	17	0	176
2437169.50	81540	39540	396	415	20	0	258
2437169.50	85260	35820	399	415	17	0	177
2437170.50	6030	42990	399	418	20	0	259
2437170.50	19620	29400	402	418	17	0	178
2437170.50	30750	40530	402	421	20	0	260
2437170.50	32760	42540	402	423	22	0	330
2437170.50	34500	36780	404	421	18	0	179
2437170.50	36510	38790	404	423	20	0	261
2437170.50	40290	35010	407	423	17	0	180
2437170.50	40320	42600	404	426	23	0	331
2437170.50	44100	38820	407	426	20	0	262
2437170.50	47760	35160	410	426	17	0	181
2437170.50	47820	42540	407	427	21	0	332
2437170.50	51480	38880	410	427	18	0	263

Table 3

Earth Parameters.

Constant	Value	Units
R	6.378165	megameters
k	4118.0870	degrees megameters$^{3/2}$ hour^{-1}
k_2	0.02201451	megameters^2
A_{30}	0.00059678	megameters^3
k_4	0.00111709	megameters^4
A_{50}	0.00000000	megameters^5

Table 4a

Elements of 95 Arcs and Accuracy of Representation of the Observations.

	t	Orbit	Half-arc length	S_1 Megameters	S_2	S_3	S_4	S_5	S_6	N	P_α	P_δ	ϵ_α	ϵ_δ	Ser. no. of arc
+Δ	$-48^h.48$	25	3810^s	7.9836359	0.01083551	47°.236384	248°.66125	13°.32318	234°.44836	34	1.67	0.33	0°.00218	0°.00488	14
	-47.84	128	570	7.9840804	0.01090705	47.245339	248.58062	13.90067	350.09129	16	0.94	1.06	0.00273	0.00263	1
	-47.71	129	1050	7.9856459	0.01108325	47.242136	248.56246	13.81841	14.52836	21	0.75	1.25	0.00290	0.00226	4
±	-47.56	130	7110	7.9856257	0.01108163	47.241992	248.54316	13.85388	41.89031	22	0.74	1.26	0.00291	0.00224	37
Δ	-46.79	131	4350	7.9856308	0.01108221	47.242001	248.44467	13.94867	181.82435	22	0.74	1.26	0.00291	0.00224	15
±	-46.38	132	11370	7.9856227	0.01108128	47.241987	248.39115	13.99963	257.87642	22	0.74	1.26	0.00291	0.00224	73
±	-45.62	133	14070	7.9856302	0.01108211	47.242002	248.29480	14.09229	34.76818	22	0.74	1.26	0.00291	0.00224	119
±	-45.61	134	8610	7.9856312	0.01108222	47.242002	248.29266	14.09454	37.80997	22	0.74	1.26	0.00291	0.00224	38
*	-45.32	33	7590	7.9837326	0.01084860	47.236400	248.25636	14.32740	89.48825	17	1.76	0.24	0.00142	0.00389	16
*	-44.86	34	11310	7.9837123	0.01084916	47.238206	248.19602	14.20833	174.87300	41	1.33	0.67	0.00434	0.00615	74
*	-44.72	35	11820	7.9837040	0.01085021	47.238312	248.17769	14.21581	200.75030	47	1.33	0.67	0.00462	0.00648	120
*	-44.58	36	10290	7.9836898	0.01089866	47.237140	248.15886	14.13650	226.70890	24	1.28	0.72	0.00391	0.00520	39
*	-44.43	37	10800	7.9836804	0.01091301	47.237236	248.14054	14.11175	252.61696	30	1.15	0.85	0.00399	0.00464	75
* +	-43.74	38	7290	7.9836701	0.01089256	47.237617	248.05182	14.22245	18.88373	18	1.29	0.71	0.00348	0.00468	17
*	-43.60	39	7800	7.9836608	0.01090346	47.237741	248.03351	14.20595	44.78404	24	1.12	0.88	0.00346	0.00391	40
*	-43.54	135	14010	7.9836541	0.01094052	47.237284	248.02533	14.07603	55.57044	39	0.75	1.25	0.00553	0.00429	121
*	-42.71	41	11010	7.9836385	0.01092019	47.237949	247.91824	14.22725	207.68235	33	0.74	1.26	0.00442	0.00340	76
*	-42.46	42	11910	7.9836462	0.01093058	47.238431	247.88645	14.20088	253.38545	44	1.09	0.91	0.00370	0.00406	122
*	-41.90	43	13920	7.9836507	0.01095174	47.238529	247.81511	14.24627	355.35338	48	1.19	0.81	0.00392	0.00474	197
*	-41.55	44	6840	7.9836064	0.01091254	47.239085	247.76761	14.49873	59.05784	24	1.06	0.94	0.00175	0.00186	41
*	-41.30	45	7740	7.9836478	0.01093838	47.239567	247.73571	14.34011	104.89125	35	1.40	0.60	0.00218	0.00334	77
	-40.78	46	4080	7.9835984	0.01092012	47.238719	247.66828	14.46058	199.17579	20	1.58	0.42	0.00082	0.00158	18
*	-40.74	47	9750	7.9836540	0.01096124	47.239450	247.66486	14.37812	206.86595	39	1.46	0.54	0.00252	0.00412	123
Δ	-40.53	49	4980	7.9835999	0.01093969	47.240352	247.63758	14.31333	244.99209	31	1.53	0.47	0.00119	0.00214	42
*	-40.50	50	10620	7.9836455	0.01096789	47.239589	247.63382	14.39197	251.00787	44	1.39	0.61	0.00267	0.00403	198
+	-40.34	51	4200	7.9836163	0.01094911	47.240346	247.61419	14.32640	280.00332	25	1.64	0.36	0.00090	0.00193	19
*	-39.98	52	6990	7.9836314	0.01096761	47.240223	247.56688	14.39516	346.92842	35	1.40	0.60	0.00247	0.00377	78
*	-39.78	53	6300	7.9836326	0.01098564	47.239619	247.54500	14.39693	21.94372	29	1.68	0.32	0.00158	0.00363	43
*	-39.73	54	7860	7.9836231	0.01097104	47.240363	247.53593	14.40637	31.07314	40	1.39	0.61	0.00237	0.00357	124
*	-39.54	55	7170	7.9836228	0.01098995	47.239830	247.51394	14.40859	66.08804	34	1.58	0.42	0.00164	0.00317	79
	-39.47	136	1140	7.9841991	0.01097380	47.241615	247.50176	14.75619	79.44865	19	1.44	0.56	0.00080	0.00129	6
	-38.91	57	3150	7.9837930	0.01095886	47.240786	247.43018	14.59755	181.62042	23	1.63	0.37	0.00081	0.00170	20
Δ	-38.67	58	4020	7.9836472	0.01099409	47.240138	247.40136	14.51924	225.85298	28	1.41	0.59	0.00173	0.00267	44
*	-38.62	59	11850	7.9836149	0.01097532	47.240306	247.39237	14.51352	233.47552	50	1.38	0.62	0.00244	0.00364	199
	-38.44	137	3210	7.9836035	0.01099229	47.239691	247.37063	14.64661	266.83797	19	1.77	0.23	0.00109	0.00282	21
*	-38.43	61	11160	7.9836147	0.01099481	47.239750	247.37142	14.52111	268.48499	44	1.49	0.51	0.00189	0.00324	125
*	-37.70	62	13800	7.9836046	0.01098248	47.241189	247.27339	14.57802	42.42349	51	1.07	0.93	0.00414	0.00444	200
*	-37.56	63	8010	7.9836221	0.01100022	47.239776	247.25907	14.63017	68.25131	38	1.37	0.63	0.00206	0.00302	80
*	-37.33	138	7200	7.9836200	0.01100653	47.239385	247.23045	14.68497	109.30678	29	1.33	0.67	0.00202	0.00283	45
*	-36.82	65	10650	7.9836045	0.01098426	47.241362	247.16077	14.68559	202.19234	45	1.07	0.93	0.00435	0.00468	126
+	-36.79	139	5250	7.9836000	0.01100115	47.239965	247.15899	14.67662	208.28715	18	1.49	0.51	0.00250	0.00101	22
*	-36.60	67	9840	7.9836043	0.01100322	47.243613	247.12920	14.68463	243.30469	36	1.08	0.92	0.00419	0.00453	81
*	-36.49	68	11850	7.9836128	0.01098748	47.241715	247.11689	14.65576	263.12680	48	0.94	1.06	0.00553	0.00521	201
*	-36.27	69	11040	7.9836270	0.01101571	47.245037	247.08551	14.57770	304.31529	39	0.78	1.22	0.00558	0.00446	127
*	-36.06	70	7890	7.9835832	0.01101816	47.243826	247.05859	14.61326	342.34403	25	0.75	1.25	0.00495	0.00384	46
*	-35.79	71	14370	7.9836143	0.01100162	47.243785	247.02507	14.69239	30.99081	55	0.95	1.05	0.00611	0.00582	279
*	-35.75	72	6780	7.9835792	0.01107261	47.243463	247.01425	14.48562	38.80676	21	0.36	1.64	0.00377	0.00176	23
*	-35.72	73	9090	7.9835957	0.01103445	47.245113	247.01565	14.50867	43.35141	28	0.64	1.36	0.00566	0.00388	82
*	-35.57	74	13560	7.9836286	0.01102684	47.246211	246.99519	14.60544	72.18748	46	0.88	1.12	0.00527	0.00467	202
*	-35.42	75	7980	7.9835970	0.01107059	47.245464	246.97357	14.44047	99.75531	24	0.51	1.49	0.00406	0.00238	47
*	-35.02	76	11610	7.9836117	0.01104048	47.246162	246.92534	14.57570	171.18493	35	0.73	1.27	0.00531	0.00403	128
*	-34.72	77	10500	7.9836179	0.01105728	47.245712	246.88447	14.55271	227.54456	31	0.59	1.41	0.00427	0.00276	83
	-34.69	78	2970	7.9835428	0.01108506	47.244323	246.87731	14.65445	232.01312	16	0.51	1.49	0.00333	0.00195	7
Δ	-34.36	79	4170	7.9836234	0.01107563	47.246054	246.83736	14.55446	293.01569	19	0.40	1.60	0.00410	0.00205	24
*	-33.66	80	6690	7.9836383	0.01106656	47.246190	246.74870	14.63733	60.83293	26	0.52	1.48	0.00395	0.00234	48

Table 4a (continued)

	t	Orbit	Half-arc length	S_1	S_2	S_3	S_4	S_5	S_6	N	P_α	P_δ	ϵ_α	ϵ_δ	Ser. no. of arc
				Megameters											
+	$-32^h.83$	31	3000^s	7.9836544	0.01107438	47°.243736	246°.65002	14°.70137	202°.37164	16	0.50	1.50	0°.00410	0°.00237	25
*	-29.38	140	14280	7.9836149	0.01113468	47.237570	246.19183	14.90775	121.66806	16	0.12	1.88	0.01769	0.00600	26
* + Δ	-23.79	84	7590	7.9835519	0.01129864	47.234789	245.48470	15.26080	62.09053	16	0.42	1.58	0.00653	0.00337	52
*	-22.90	85	10800	7.9835541	0.01125770	47.234890	245.37013	15.33025	225.79453	18	0.39	1.61	0.00650	0.00320	88
*	-22.73	86	11400	7.9835572	0.01127262	47.236207	245.35112	15.38064	256.24406	25	0.48	1.52	0.00631	0.00354	134
*	-21.93	87	14130	7.9835508	0.01127093	47.236796	245.25133	15.45709	34.73011	35	0.83	1.17	0.00605	0.00509	209
*	-21.63	88	7620	7.9835899	0.01125675	47.236990	245.21654	15.64419	87.83694	18	0.30	1.70	0.00336	0.00141	89
*	-20.92	89	10350	7.9835534	0.01126698	47.237921	245.11630	15.63952	226.40227	28	1.25	0.75	0.00394	0.00509	135
Δ	-20.81	141	4470	7.9835887	0.01125144	47.237052	245.10410	15.77459	247.58398	16	0.48	1.52	0.00137	0.00191	53
*	-20.73	91	10890	7.9835499	0.01127534	47.238093	245.09691	15.64419	253.80468	39	1.26	0.74	0.00338	0.00443	210
*	-20.05	92	7200	7.9835486	0.01126745	47.238127	245.00382	15.74382	26.17581	26	1.17	0.83	0.00410	0.00487	90
*	-19.90	93	7740	7.9835454	0.01127339	47.238276	244.98446	15.74966	53.57723	37	1.17	0.83	0.00349	0.00412	136
*	-19.88	94	14100	7.9835335	0.01129875	47.238017	244.98218	15.68039	56.68979	44	0.91	1.09	0.00672	0.00613	288
*	-19.87	95	6540	7.9835410	0.01129530	47.239671	244.97840	15.70005	59.71654	19	1.05	0.95	0.00344	0.00361	54
*	-19.72	96	7080	7.9835472	0.01129233	47.239541	244.95923	15.71252	87.11200	30	1.03	0.97	0.00279	0.00289	91
*	-19.01	97	10950	7.9835259	0.01129459	47.238142	244.86975	15.79393	216.45513	42	0.83	1.17	0.00689	0.00580	211
	-18.98	98	3360	7.9834959	0.01129273	47.239954	244.86479	15.88320	220.93493	18	0.79	1.21	0.00364	0.00295	28
*	-18.86	99	11490	7.9835228	0.01129884	47.238474	244.85056	15.80896	243.84764	50	0.89	1.11	0.00629	0.00562	289
+ Δ	-18.83	100	3900	7.9835346	0.01129741	47.239644	244.84575	15.85097	248.37483	29	0.95	1.05	0.00283	0.00269	55
*	-18.82	102	10290	7.9835055	0.01130015	47.239141	244.84474	15.84885	249.89902	35	0.97	1.03	0.00628	0.00608	137
	-18.69	103	3330	7.9835781	0.01131197	47.240014	244.82487	15.75222	277.40199	26	0.81	1.19	0.00257	0.00212	29
*	-18.68	104	10830	7.9835104	0.01130437	47.239331	244.82545	15.84302	277.31226	43	1.00	1.00	0.00568	0.00567	212
*	-18.21	105	13830	7.9835550	0.0114799[illegible]	47.239065	244.76037	15.53678	2.86626	58	1.30	0.70	0.01303	0.01777	357
*	-18.02	106	13170	7.9835894	0.01148022	47.241335	244.74262	15.43434	36.41879	51	1.26	0.74	0.01323	0.01736	290
	-17.98	107	840	7.9835123	0.01128954	47.239695	244.73619	15.96203	43.67340	20	0.70	1.30	0.00230	0.00168	9
*	-17.94	108	7110	7.9834802	0.01128971	47.23[illegible]	244.73144	16.02790	51.12397	34	0.89	1.11	0.00630	0.00564	92
*	-17.79	109	7650	7.9835001	0.01129478	47.239969	244.71202	15.97856	78.57954	42	0.93	1.07	0.00577	0.00537	138
*	-17.73	110	6540	7.9834755	0.01128312	47.239255	244.71091	16.05740	80.02546	31	0.92	1.08	0.00641	0.00591	56
*	-17.63	111	7030	7.9835029	0.01130036	47.239525	244.69148	15.98160	107.50666	39	0.95	1.05	0.00583	0.00554	93
*̲	-17.14	112	9990	7.9836011	0.01147792	47.241549	244.62889	15.59530	197.70759	50	1.24	0.76	0.01340	0.01711	213
	-17.09	113	4050	7.9834229	0.01127672	47.239178	244.62142	15.97124	206.49243	25	0.78	1.22	0.00675	0.00540	30
*̲	-16.98	114	9420	7.9836181	0.01146075	47.241924	244.60825	15.59765	226.63537	47	1.19	0.81	0.01369	0.01659	139
	-16.95	115	3540	7.9834501	0.01157072	47.240359	244.62671	15.47238	232.82650	16	0.72	1.28	0.00793	0.00595	10
Δ	-16.94	116	4590	7.9834493	0.01129238	47.240465	244.60315	15.87624	233.99136	33	0.86	1.14	0.00586	0.00599	57
	-16.[illegible]	117	4000	7.9834644	0.01141687	47.239896	244.59584	15.72890	260.00289	24	0.77	1.23	0.00663	0.00525	31
*̲	-16.29	118	6930	7.9838828	0.01148970	47.236506	244.51795	16.58205	352.03158	45	1.15	0.85	0.02160	0.02512	94
*̲	-16.15	142	6420	7.9841558	0.01130751	47.193566	244.46174	21.73987	12.81815	29	1.80	0.20	0.00864	0.02610	58
± Δ̲	-15.72	143	3030	7.9857262	0.01103334	47.244785	244.21880	18.50838	186.57384	31	1.72	0.28	0.00864	0.02154	32
	-15.08	144	2530	7.9857324	0.01114215	47.224835	244.30882	19.99655	209.43828	24	1.99	0.01	0.00129	0.01878	11
	-14.53	145	480	8.0008403	0.01284209	47.214995	244.20103	10.44017	325.51067	19	0.51	1.49	0.00165	0.00097	2

Table 4b

Elements of Five One-Day Arcs and Accuracy of Representation of the Observations.

t	Orbit	S_1 Megameters	S_2	S_3	S_4	S_5	S_6	S_{18}	N	P_α	P_δ	ϵ_α	ϵ_δ
$-60^h.00$	182	7.9837288	0.01058634	47°.235828	250°.14102	13°.84211	288°.68957	+2°.4274	36	1.84	0.16	0°.00316	0°.01067
-36.00	183	7.9836192	0.01092532	47.239197	247.05455	14.79021	352.83010	+1.0900	110	0.70	1.30	0.01301	0.00960
-12.00	184	7.9834862	0.01143574	47.238439	243.97053	16.38444	56.40552	+1.2165	65	1.33	0.67	0.00931	0.01306
+12.00	185	7.9833360	0.01170873	47.238748	240.88847	18.30955	119.78057	+1.3944	29	0.94	1.06	0.00639	0.00605
+36.00	186	7.9831923	0.01217194	47.238536	237.79791	20.64156	182.86631	+1.7216	37	0.49	1.51	0.01059	0.00604

Table 4c

Elements of Additional Arcs and Accuracy of Representation of the Observations.

t	Orbit	Half-arc length	S_1 Megameters	S_2	S_3	S_4	S_5	S_6	N	P_α	P_δ	ϵ_α	ϵ_δ	Ser. no. of arc
Δ $-96^h.81$	169	7650^s	7.9838185	0.01022004	47°.236167	254°.87745	11°.27904	46°.10580	14	0.45	1.55	0°.00655	0°.00353	564
Δ -68.22	170	3960	7.9837841	0.01034496	47.238570	251.18713	13.11044	228.19013	11	1.96	0.04	0.00138	0.01019	565
Δ -62.54	171	3090	7.9839057	0.01062879	47.242220	250.47079	13.18903	184.94976	8	1.80	0.20	0.00068	0.00202	566
Δ -44.49	172	4590	7.9837471	0.01084383	47.237608	248.14996	14.46106	241.61413	11	1.72	0.28	0.00157	0.00389	567
Δ -42.44	173	3630	7.9836822	0.01093498	47.239135	247.88194	14.25678	256.37611	15	1.84	0.16	0.00059	0.00200	568
Δ -36.48	174	4140	7.9835622	0.01105415	47.242007	247.12181	14.41388	264.87906	14	1.59	0.41	0.00094	0.00184	569
Δ - 0.28	180	7140	7.9834343	0.01148891	47.229719	242.45806	17.85655	35.81815	10	2.00	0.00	0.00034	0.00803	570
Δ +11.62	181	8730	7.9833953	0.01178166	47.237516	240.94113	18.31681	51.24439	11	0.44	1.56	0.00450	0.00244	571
Δ +31.72	177	8130	7.9831977	0.01211227	47.239399	238.35053	19.96009	122.38361	9	1.84	0.16	0.00062	0.00211	572
Δ +33.40	178	7740	7.9831897	0.01212569	47.238657	238.13554	20.18688	68.22365	11	1.83	0.17	0.00062	0.00207	573
Δ +46.98	179	7140	7.9831393	0.01235526	47.235261	236.38526	21.30864	29.17637	8	1.16	0.84	0.00130	0.00153	574

Table 5a

Probable Errors of the Elements of 95 Arcs of Table 4a.

	t	Orbit	Half-arc length	Probable Error of $S_1 \cdot 10^7$	$S_2 \cdot 10^8$	$S_3 \cdot 10^6$	$S_4 \cdot 10^5$	$S_5 \cdot 10^5$	$S_6 \cdot 10^5$	Ser. no. of arc
+ Δ	$-48^{h}.48$	25	3810^{s}	38	241	335	41	2872	2822	14
	-47.84	128	570	6761	7643	1179	46	13015	12846	1
	-47.71	129	1050	1523	1840	501	31	3323	3252	4
*̲	-47.56	130	7110	1472	1775	485	31	3197	3130	37
Δ̲	-46.79	131	4350	1473	1777	487	31	3198	3155	15
*̲	-46.38	132	11370	1459	1761	485	31	3201	3193	73
*̲	-45.62	133	14070	1449	1751	489	31	3204	3281	119
*̲	-45.61	134	8610	1451	1755	491	31	3205	3280	38
*	-45.32	33	7590	31	585	368	56	2763	2678	16
*	-44.86	34	11310	31	393	454	44	2629	2581	74
*	-44.72	35	11820	31	415	455	46	2757	2706	120
*	-44.58	36	10290	40	814	422	56	3311	3232	39
*	-44.43	37	10800	33	704	364	51	2970	2900	75
+ *	-43.74	38	7290	49	805	448	53	3092	3022	17
*	-43.60	39	7800	39	666	358	46	2624	2565	40
*	-43.54	135	14010	25	703	361	54	2975	2906	121
*	-42.71	41	11010	25	626	343	45	2524	2467	76
*	-42.46	42	11910	22	536	286	39	1844	1797	122
*	-41.90	43	13920	24	484	317	42	1905	1863	197
*	-41.55	44	6340	41	390	195	25	2040	2002	41
*	-41.30	45	7740	29	440	240	35	1427	1392	77
	-40.78	46	4080	28	279	254	29	2286	2227	18
*	-40.74	47	9750	33	392	285	39	1515	1488	123
Δ	-40.53	49	4980	34	276	178	24	1205	1175	42
*	-40.50	50	10620	29	377	281	39	1500	1473	198
+	-40.34	51	4290	45	463	165	38	1263	1210	19
*	-39.98	52	6990	57	391	326	42	2002	1963	78
*	-39.78	53	6300	74	407	285	42	1783	1746	43
*	-39.73	54	7860	41	343	299	39	1701	1669	124
*	-39.54	55	7170	43	320	258	40	1471	1443	79
	-39.47	136	1140	639	444	202	31	3574	3564	6
	-38.91	57	3150	95	260	169	26	1037	1020	20
Δ	-38.67	58	4020	64	329	268	41	1337	1315	44
*	-38.62	59	11850	28	340	284	39	1627	1599	199
	-38.44	137	3210	114	268	449	58	2623	2607	21
*	-38.43	61	11160	27	330	255	43	1492	1465	125
*	-37.70	62	13300	27	511	413	60	2081	2036	200
*	-37.56	63	8010	34	370	279	46	1474	1450	80
*	-37.33	138	7200	43	386	500	80	2200	2187	45
*	-36.82	65	10650	33	561	471	64	2283	2233	126
+	-36.79	139	5250	140	583	860	143	6009	5982	22
*	-36.60	67	9840	57	627	635	76	3590	3540	81
*	-36.49	68	11850	33	663	531	72	2453	2399	201
*	-36.27	69	11040	42	720	651	82	2982	2934	127
*	-36.06	70	7890	71	753	856	107	4323	4237	46
*	-35.79	71	14370	27	679	515	69	2524	2465	279
*	35.75	72	6730	60	785	535	65	2820	2751	23
*	-35.72	73	9090	62	775	730	97	3474	3402	82
*	-35.57	74	13560	34	609	482	61	2692	2643	202
*	-35.42	75	7980	56	859	540	73	2981	2903	47
*	-35.02	76	11610	42	621	573	74	2823	2763	128
*	-34.72	77	10500	37	584	448	60	2226	2176	83
	-34.69	78	2970	200	884	703	97	4025	3943	7

Table 5a (continued)

t	Orbit	Half-arc length	Probable Error of $S_1 \cdot 10^7$	$S_2 \cdot 10^8$	$S_3 \cdot 10^6$	$S_4 \cdot 10^5$	$S_5 \cdot 10^5$	$S_6 \cdot 10^5$	Ser. no. of arc
h									
Δ̲ -34.36	79	4170	84	825	578	72	2819	2755	24
*̲ -33.66	80	6690	46	531	420	55	2138	2092	48
+ -32.88	81	3900	77	699	587	72	2631	2574	25
* -29.38	140	14280	56	2235	939	192	6582	6427	26
*+Δ -23.79	84	7590	53	1568	409	77	4092	3952	52
* -22.90	85	10800	44	1456	375	72	3860	3724	88
* -22.73	86	11400	32	1338	271	50	2870	2778	134
* -21.98	87	14130	28	937	322	50	2922	2844	209
* -21.68	88	7620	35	760	150	27	2030	1968	89
* -20.92	89	10350	43	914	336	48	2839	2760	135
Δ -20.81	141	4470	66	892	175	31	2663	2601	53
* -20.78	91	10890	31	676	269	40	2226	2167	210
* -20.05	92	7200	48	922	343	47	2871	2796	90
* -19.90	93	7740	34	663	267	39	2195	2138	136
* -19.88	94	14100	45	1010	402	62	3521	3436	288
* -19.87	95	6540	99	848	332	45	2975	2931	54
* -19.72	96	7080	59	554	236	34	2172	2138	91
* -19.01	97	10950	49	992	402	61	3491	3408	211
-18.98	98	3360	165	802	309	42	3408	3359	28
* -18.86	99	11490	38	878	358	56	3065	2990	289
+Δ -18.83	100	3900	82	568	235	33	2449	2405	55
* -18.82	102	10290	94	1127	472	69	4515	4425	137
-18.68	103	3330	104	608	216	29	2900	2848	29
* -18.68	104	10830	60	957	407	62	3533	3456	212
* -18.21	105	13830	90	1236	971	144	5714	5625	357
* -18.02	106	13170	135	1288	1087	161	6128	6055	290
-17.98	107	840	1349	1176	519	60	5202	5175	9
* -17.94	108	7110	114	1155	462	67	4802	4690	92
* -17.79	109	7650	67	972	403	60	3576	3491	138
* -17.78	110	6540	150	1405	519	72	6039	5890	56
* -17.63	111	7030	78	1082	441	64	3966	3868	93
*̲ -17.14	112	9990	145	1299	1104	161	6142	6064	213
-17.09	113	4050	189	1635	1116	133	8572	8348	30
*̲ -16.98	114	9420	152	1311	1154	162	6264	6180	139
-16.95	115	3540	259	10894	1661	815	23584	21914	10
Δ -16.94	116	4590	124	1189	697	89	5893	5752	57
-16.80	117	4080	144	5119	848	371	9336	8715	31
*̲ -16.29	118	6930	398	2156	2676	316	19717	19375	94
*̲ -16.15	142	6420	429	1823	2974	356	15754	15698	58
·+̲Δ̲ -15.22	143	3060	983	2088	2932	298	14982	14900	32
-15.08	144	2580	518	762	1221	205	6607	6668	11
-14.50	145	480	10578	10142	1166	110	27629	27747	2

Table 5b

Probable Errors of Elements of 5 Arcs of Table 4b.

t	Orbit	Probable Error of $S_1 \cdot 10^7$	$S_2 \cdot 10^8$	$S_3 \cdot 10^6$	$S_4 \cdot 10^5$	$S_5 \cdot 10^5$	$S_6 \cdot 10^5$	$S_{18} \cdot 10^4$
$- 60^h.00$	182	8	761	639	106	3943	3834	886
- 36.00	183	16	735	535	69	3239	3178	704
- 12.00	184	17	950	623	102	4124	4057	1162
+ 12.00	185	17	988	613	95	4128	4069	1252
+ 36.00	186	16	1383	820	140	3803	3742	1055

Table 5c

Probable Errors of Elements of Additional Arcs of Table 4c.

t	Orbit	Half-arc length	Probable Error of $S_1 \cdot 10^7$	$S_2 \cdot 10^8$	$S_3 \cdot 10^6$	$S_4 \cdot 10^5$	$S_5 \cdot 10^5$	$S_6 \cdot 10^5$	Ser. no. of arc
Δ $-96^h.81$	169	7660^s	101	723	614	98	8546	8378	564
$\bar{\Delta}$ -68.22	170	3960	262	3164	837	282	8659	8160	565
$\bar{\Delta}$ -62.54	171	3000	239	597	448	54	2236	2199	566
$\bar{\Delta}$ -44.49	172	4590	360	1028	531	68	13215	13054	567
$\bar{\Delta}$ -42.44	173	3630	57	282	185	25	1786	1765	568
Δ -36.48	174	4140	78	3306	875	272	4074	4148	569
Δ - 0.28	180	7140	7	732	182	106	2269	2203	570
$\bar{\Delta}$ +11.62	181	8730	79	1126	1170	186	3505	3446	571
$\bar{\Delta}$ +31.72	177	8130	79	960	478	73	2314	2361	572
Δ +33.40	178	7740	38	622	397	54	2234	2273	573
Δ +46.98	179	7140	40	1091	399	56	8552	8318	574

Table 6a

Elements of 68 Orbits.

t	Orbit	Half - arc length	S_1 Megameters	S_2	S_3	S_4	S_5	S_6	ΔΩ	Δω	ΔM	Ser. no. of arc
0-47ʰ.56	130	7110ˢ	7.9856257	0.01108163	47.241992	248°.54316	13°.85388	41°.89031	+ 0°.00203	+ 1°.50115	- 1°.41502	37
0-46.38	132	11370	7.9856227	0.01108128	47.241987	248.39115	13.99963	257.87642	+ 0.00219	+ 1.50087	- 1.49892	73
0-45.62	133	14070	7.9856302	0.01108211	47.242002	248.29480	14.09229	34.76818	+ 0.00228	+ 1.50097	- 1.55294	119
0-45.61	134	8610	7.9856312	0.01108222	47.242002	248.29266	14.09454	37.80997	+ 0.00229	+ 1.50116	- 1.55440	38
-45.32	33	7590	7.9837326	0.01084860	47.236400	248.25636	14.32740	89.48825	+ 0.00242	+ 1.69906	- 1.61119	16
-44.86	34	11310	7.9837123	0.01084816	47.238206	248.19602	14.20833	174.87300	+ 0.00209	+ 1.52240	- 1.43715	74
-44.72	35	11820	7.9837040	0.01085021	47.238312	248.17769	14.21581	200.75030	+ 0.00198	+ 1.51239	- 1.42738	120
-44.58	36	10290	7.9836898	0.01089866	47.237140	248.15886	14.13650	226.70890	+ 0.00137	+ 1.41560	- 1.33632	39
-44.43	37	10800	7.9836804	0.01091301	47.237236	248.14054	14.11175	252.61696	+ 0.00126	+ 1.37337	- 1.29580	75
-43.74	38	7290	7.9836701	0.01099256	47.237617	248.05182	14.22245	18.88373	+ 0.00149	+ 1.39871	- 1.32347	17
-43.60	39	7800	7.9836608	0.01090346	47.237741	248.03351	14.20595	44.78404	+ 0.00139	+ 1.36473	- 1.29070	40
-43.54	135	14010	7.9836541	0.01094052	47.237284	248.02533	14.07603	55.57044	+ 0.00071	+ 1.22761	- 1.15563	121
-42.71	41	11010	7.9836385	0.01092019	47.237949	247.91824	14.22725	207.68235	+ 0.00078	+ 1.27599	- 1.20570	76
-42.46	42	11910	7.9836462	0.01093058	47.238431	247.88645	14.20088	253.38545	+ 0.00114	+ 1.21876	- 1.15119	122
-41.90	43	13920	7.9836507	0.01095174	47.238529	247.81511	14.24627	355.35338	+ 0.00160	+ 1.19525	- 1.13180	197
-41.55	44	6840	7.9836064	0.01091284	47.239085	247.76761	14.49873	59.05784	- 0.00089	+ 1.40452	- 1.33538	41
-41.30	45	7740	7.9836478	0.01093838	47.239567	247.73571	14.34011	104.89125	- 0.00065	+ 1.21505	- 1.15056	77
-40.74	47	9750	7.9836540	0.01096124	47.239450	247.66486	14.37812	206.86595	+ 0.00030	+ 1.18415	- 1.12438	123
-40.50	50	10620	7.9836455	0.01096789	47.239589	247.63382	14.39197	251.00787	+ 0.00034	+ 1.16818	- 1.10944	198
-39.98	52	6990	7.9836314	0.01096761	47.240223	247.56688	14.39516	346.92842	+ 0.00091	+ 1.10658	- 1.05094	78
-39.78	53	6300	7.9836326	0.01098564	47.239619	247.54500	14.39693	21.94372	+ 0.00367	+ 1.08470	- 1.03289	43
-39.73	54	7860	7.9836231	0.01097104	47.240363	247.53593	14.40637	31.07314	+ 0.00103	+ 1.08797	- 1.03320	124
-39.54	55	7170	7.9836228	0.01098995	47.239830	247.51394	14.40859	66.08804	+ 0.00369	+ 1.06653	- 1.01555	79
-38.62	59	11850	7.9836149	0.01097532	47.240306	247.39337	14.51352	233.47552	+ 0.00100	+ 1.05834	- 1.00625	199
-38.43	61	11160	7.9836147	0.01099481	47.239750	247.37142	14.52111	268.48499	+ 0.00369	+ 1.04227	- 0.99403	125
-37.70	62	13800	7.9836046	0.01098248	47.241189	247.27339	14.57802	42.42349	- 0.00004	+ 1.00868	- 0.95808	200
-37.56	63	8010	7.9836221	0.01100022	47.239776	247.25907	14.63027	68.25131	+ 0.00386	+ 1.04345	- 0.99779	80
-37.33	138	7200	7.9836200	0.01100653	47.239385	247.23045	14.68497	109.30678	+ 0.00417	+ 1.07038	- 1.02605	45
-36.82	65	10650	7.9836045	0.01098476	47.241362	247.16077	14.68559	202.19234	- 0.00014	+ 1.00827	- 0.95931	126
-36.60	67	9840	7.9836043	0.01100322	47.243613	247.12920	14.68463	243.30469	- 0.00278	+ 0.97954	- 0.93070	81
-36.49	68	11850	7.9836128	0.01098748	47.241715	247.11689	14.65576	263.12680	- 0.00116	+ 0.93731	- 0.88964	201
-36.27	69	11040	7.9836270	0.01101571	47.245037	247.08551	14.57770	304.31529	- 0.00360	+ 0.83148	- 0.78487	127
-36.06	70	7890	7.9835832	0.01101816	47.243826	247.05859	14.61326	342.34403	- 0.00373	+ 0.84133	- 0.79663	46
-35.79	71	14370	7.9836143	0.01100152	47.243785	247.02507	14.69239	30.99081	- 0.00296	+ 0.88755	- 0.84169	279
-35.75	72	6780	7.9835792	0.01107261	47.243463	247.01425	14.48562	38.80676	- 0.00842	+ 0.67564	- 0.63385	23
-35.72	73	9090	7.9835957	0.01103445	47.245113	247.01565	14.50867	43.35141	- 0.00381	+ 0.69560	- 0.65406	82
-35.57	74	13560	7.9836286	0.01102684	47.246211	246.99519	14.60544	72.18748	- 0.00391	+ 0.77283	- 0.72876	202
-35.42	75	7980	7.9835970	0.01107059	47.245464	246.97357	14.44047	99.75531	- 0.00624	+ 0.58935	- 0.55009	47
-35.02	76	11610	7.9836117	0.01104048	47.246162	246.92534	14.57570	171.18493	- 0.00410	+ 0.67625	- 0.63659	128
-34.72	77	10500	7.9836179	0.01105728	47.245712	246.88447	14.55271	227.54456	- 0.00532	+ 0.61520	- 0.57690	83
-33.66	80	6690	7.9836383	0.01106656	47.246190	246.74870	14.63733	60.83293	- 0.00500	+ 0.56922	- 0.53424	48
-29.38	140	14280	7.9836149	0.01113468	47.237570	246.19183	14.90775	121.66806	- 0.01214	+ 0.31206	- 0.29008	26
-23.79	84	7590	7.9835519	0.01125864	47.234789	245.48470	15.26080	62.99053	- 0.00023	- 0.02495	+ 0.02549	52
-22.90	85	10800	7.9835541	0.01125770	47.234890	245.37013	15.38025	225.79453	- 0.00014	- 0.01554	+ 0.01616	88
-22.73	86	11400	7.9835572	0.01127263	47.236207	245.35112	15.38064	256.24406	+ 0.00228	- 0.03572	+ 0.03329	134
-21.98	87	14130	7.9835508	0.01127088	47.236796	245.25133	15.45709	34.73011	+ 0.00001	- 0.05285	+ 0.05194	209
-21.68	88	7620	7.9835899	0.01125675	47.236999	245.21654	15.64419	87.83694	+ 0.00272	+ 0.09826	- 0.09793	89
-20.92	89	10350	7.9835534	0.01126698	47.237921	245.11630	15.63952	226.40227	0.00000	0.00000	0.00000	135
-20.78	91	10890	7.9835499	0.01127384	47.238098	245.09691	15.64419	253.80468	- 0.00010	- 0.01384	+ 0.01326	210
-20.05	92	7200	7.9835486	0.01126745	47.238127	245.00382	15.74382	26.17581	+ 0.00004	- 0.00368	+ 0.00346	90
-19.90	93	7740	7.9835454	0.01127329	47.238276	244.98446	15.74966	53.57723	- 0.00003	- 0.01635	+ 0.01573	136
-19.88	94	14100	7.9835335	0.01129875	47.238017	244.98218	15.68039	56.68979	- 0.00017	- 0.08768	+ 0.08506	288
-19.87	95	6540	7.9835410	0.01129530	47.239671	244.97840	15.70005	59.71654	- 0.00181	- 0.07008	+ 0.06856	54
-19.72	96	7080	7.9835472	0.01129233	47.239546	244.95923	15.71252	87.11200	- 0.00169	- 0.07612	+ 0.07487	91
-19.01	97	10950	7.9835259	0.01129459	47.238142	244.86975	15.79393	216.45513	- 0.00008	- 0.08212	+ 0.08032	211
-18.86	99	11490	7.9835228	0.01129884	47.238474	244.85056	15.80896	243.84764	+ 0.00002	- 0.08560	+ 0.08365	289
-18.82	102	10290	7.9835055	0.01130015	47.239141	244.84474	15.84885	249.89902	- 0.00152	- 0.04983	+ 0.04856	137
-18.68	104	10830	7.9835104	0.01130437	47.239381	244.82545	15.84302	277.31226	- 0.00152	- 0.07417	+ 0.07264	212
-18.21	105	13830	7.9835550	0.01147989	47.239965	244.76837	15.53678	2.86626	+ 0.00141	- 0.43800	+ 0.41595	357
-18.02	106	13170	7.9835894	0.01148022	47.241385	244.74262	15.48434	36.41879	- 0.00077	- 0.51307	+ 0.49283	290
-17.94	108	7110	7.9834802	0.01128371	47.239138	244.73144	16.02790	51.12397	- 0.00123	+ 0.02021	- 0.01819	92
-17.79	109	7650	7.9835001	0.01129478	47.239368	244.71202	15.97856	78.57954	- 0.00136	- 0.04764	+ 0.04823	138
-17.78	110	6540	7.9834755	0.01128312	47.239285	244.71091	16.05740	80.02546	- 0.00140	+ 0.03017	- 0.02747	56
-17.63	111	7080	7.9835029	0.01130036	47.239525	244.69148	15.98160	107.50666	- 0.00154	- 0.06414	+ 0.06458	93
0-17.14	112	9990	7.9836011	0.01147792	47.241549	244.62889	15.59530	197.70759	- 0.00091	- 0.51112	+ 0.48993	213
0-16.98	114	9420	7.9836181	0.01148075	47.241924	244.60825	15.59768	226.63537	- 0.00119	- 0.52828	+ 0.50692	139
0-16.29	118	6930	7.9838828	0.01148570	47.236506	244.51795	16.58205	352.03158	- 0.00254	+ 0.37074	- 0.39130	94
0-16.15	142	6420	7.9841558	0.01130751	47.193586	244.46174	21.73987	12.81815	- 0.04054	+ 5.51107	- 5.47227	58

Table 6b

Elements of 8 Orbits.

t	Orbit	Half-arc length	S_1	S_2	S_3	S_4	S_5	S_6	$\Delta\Omega$	$\Delta\omega$	ΔM	Ser. no. of arc
			Megameters									
$-48^{h}.48$	25	3810^{s}	7.9836359	0.01083331	47°.236384	248°.66123	13°.82318	234°.44836	+ 0°.00223	+ 1°.58357	− 1°.47877	14
−43.74	38	7290	7.9836701	0.01089256	47.237617	248.05182	14.22245	18.88373	+ 0.00149	+ 1.39871	− 1.32347	17
−40.34	51	4290	7.9836163	0.01094911	47.240346	247.61419	14.32640	280.00332	+ 0.00107	+ 1.08307	− 1.02476	19
−36.79	139	5250	7.9836000	0.01100115	47.239965	247.15899	14.67662	208.28715	+ 0.00237	+ 0.99519	− 0.95098	22
−32.88	81	3900	7.9836544	0.01107488	47.246786	246.65002	14.70137	202.37164	− 0.00402	+ 0.53762	− 0.50617	25
−23.79	84	7590	7.9835519	0.01125864	47.234789	245.48470	15.26080	62.99053	− 0.00023	− 0.02495	+ 0.02549	52
−18.83	100	3900	7.9835346	0.01128741	47.239644	244.84575	15.85097	248.37483	− 0.00158	− 0.04668	+ 0.04600	55
0 −15.22	143	3060	7.9867262	0.01103334	47.244785	244.31880	18.50838	186.57384	− 0.06346	+ 2.16440	− 2.13800	32

Table 6c

Elements of 21 Orbits.

t	Orbit	Half-arc length	S_1	S_2	S_3	S_4	S_5	S_6	$\Delta\Omega$	$\Delta\omega$	ΔM	Ser. no. of arc
			Megameters									
0 $-96^{h}.81$	169	7650^{s}	7.9838185	0.01022004	47°.236167	254°.87745	11°.27904	46°.10580	+ 0°.00318	+ 5°.00420	− 4°.42639	564
0 −68.22	170	3960	7.9837841	0.01034496	47.238570	251.18713	13.11044	228.19013	− 0.01049	+ 3.30713	− 3.01966	565
0 −62.54	171	3090	7.9839057	0.01062879	47.242220	250.47079	13.18903	184.94976	+ 0.00293	+ 2.68538	− 2.48313	566
−48.48	25	3810	7.9836359	0.01033331	47.236384	248.66123	13.82318	234.44836	+ 0.00223	+ 1.58357	− 1.47877	14
0 −46.79	131	4350	7.9856308	0.01108221	47.242001	248.44467	13.94867	181.82435	+ 0.00213	+ 1.50133	− 1.46999	15
0 −44.49	172	4590	7.9837471	0.01034383	47.237608	248.14996	14.46106	241.61413	+ 0.00318	+ 1.72988	− 1.64729	567
−42.44	173	3630	7.9836822	0.01093498	47.239135	247.88194	14.25678	256.37611	− 0.00123	+ 1.27261	− 1.20378	568
−40.53	49	4980	7.9835999	0.01093969	47.240352	247.63758	14.31833	244.99209	− 0.00019	+ 1.09865	− 1.03873	42
−38.67	58	4020	7.9836472	0.01099409	47.240138	247.40136	14.51924	225.85298	+ 0.00363	+ 1.06920	− 1.02069	44
−36.48	174	4140	7.9835622	0.01105415	47.242007	247.12181	14.41388	264.87906	+ 0.00484	+ 0.69440	− 0.65901	569
0 −34.36	79	4170	7.9836234	0.01107563	47.246054	246.83736	14.55446	293.01569	− 0.00636	+ 0.57273	− 0.53544	24
−23.79	84	7590	7.9835519	0.01125864	47.234789	245.48470	15.26080	62.99053	− 0.00023	− 0.02495	+ 0.02549	52
−20.81	141	4470	7.9835887	0.01125144	47.237052	245.10410	15.77459	247.58398	+ 0.00280	+ 0.12067	− 0.12097	53
−18.83	100	3900	7.9835346	0.01128741	47.239644	244.84575	15.85097	248.37483	− 0.00158	− 0.04668	+ 0.04600	55
−16.94	116	4590	7.9834493	0.01129238	47.240485	244.60315	15.87624	233.99136	− 0.00093	− 0.25486	+ 0.25483	57
0 −15.22	143	3060	7.9867262	0.01103334	47.244785	244.31880	18.50838	186.57384	− 0.06346	+ 2.16440	− 2.13800	32
0 − 0.28	180	7140	7.9834343	0.01148891	47.229719	242.45806	17.85655	35.81815	− 0.00389	− 0.33033	+ 0.36362	570
0 +11.62	181	8730	7.9833953	0.01178156	47.237516	240.94113	18.31681	51.24439	+ 0.01049	− 1.33967	+ 1.39511	571
+31.72	177	8130	7.9831977	0.01211227	47.239399	238.35053	19.96009	122.38361	+ 0.00458	− 2.17691	+ 2.38733	572
+33.40	178	7740	7.9831897	0.01212569	47.238657	238.13554	20.18688	68.22865	+ 0.00498	− 2.15683	+ 2.38679	573
+46.98	179	7140	7.9831393	0.01238526	47.235261	236.38526	21.30864	29.17887	+ 0.00141	− 2.71137	+ 3.09675	574

Table 7

Representations $\gamma_0 + \gamma_1 t + \gamma_2 \tau^2$

		Set I	Set II	Set III
		Values of the coefficients γ_i and probable errors		
S_1	γ_0	7.9834126 ± 73	7.9834713 ± 297	7.9833973 ± 86
	γ_1	- 0.000005752 ± 217	- 0.000003930 ± 818	- 0.000005759 ± 246
	γ_2	0.000000000	0.000000000	0.000000000
S_2	γ_0	0.01163307 ± 1048	0.01161502 ± 1792	0.01160586 ± 530
	γ_1	+ 0.0000167881 ± 3123	+ 0.0000163694 ± 4930	+ 0.0000160177 ± 1519
	γ_2	0.0000000000	0.0000000000	0.0000000000
S_3	γ_0	47°.238230 ± 838	47°.240293 ± 3959	47°.238333 ± 485
	γ_1	- 0.00005044 ± 2497	+ 0.00002663 ± 10893	- 0.00001885 ± 1392
	γ_2	0.00000000	0.00000000	0.00000000
$\Delta\Omega$	γ_0	- 0°.00221 ± 88	- 0°.00442 ± 191	+ 0°.00206 ± 53
	γ_1	- 0.0000518 ± 262	- 0.0001317 ± 524	+ 0.0000250 ± 151
	γ_2	0.0000000	0.0000000	0.0000000
$\Delta\omega$	γ_0	- 1°.27705 ± 3634	- 1°.32270 ± 11214	- 0°.99520 ± 4386
	γ_1	- 0.0598267 ± 10830	- 0.0603858 ± 30856	- 0.0437881 ± 6667
	γ_2	0.0000000	0.0000000	+ 1.8867470 ± 3097030
ΔM	γ_0	+ 1°.21241 ± 3497	+ 1°.24405 ± 10897	+ 1°.01414 ± 4365
	γ_1	+ 0.0567332 ± 10422	+ 0.0568553 ± 29985	+ 0.0468360 ± 6634
	γ_2	0.0000000	0.0000000	- 0.8939171 ± 3082003
		Probable errors of representation		
S_1		0.0000165	0.0000213	0.0000270
S_2		0.00002377	0.00001287	0.00001667
S_3		0°.001901	0°.002844	0°.001528
$\Delta\Omega$		0°.00199	0°.00137	0°.00166
$\Delta\omega$		0°.08243	0°.08055	0°.07308
ΔM		0°.07932	0°.07827	0°.07272
		Range in epochs and no. of orbits used in solution		
		$27^h.69$ 60	$29^h.65$ 7	$95^h.46$ 12

Table 8a

Residuals of Solution I for Orbits of Table 6a.

t	Orbit	Half-arc length	$\delta a \cdot 10^7$	$\delta e \cdot 10^8$	$\delta I \cdot 10^6$	$\delta \Omega \cdot 10^5$	$\delta \omega \cdot 10^5$	$\delta M \cdot 10^5$	Ser. no. of arc
0 $-47^h.56$	130	7110^s	+ 19395	+ 24700	+ 1363	+ 178	− 6716	+ 7080	37
0 −46.38	132	11370	+ 19433	+ 22684	+ 1418	+ 200	+ 316	− 8004	73
0 −45.62	133	14070	+ 19552	+ 21491	+ 1471	+ 213	+ 4873	− 17718	119
0 −45.61	134	8610	+ 19563	+ 21486	+ 1471	+ 214	+ 4951	− 17921	38
−45.32	33	7590	+ 593	− 2363	− 4116	+ 229	+ 26476	− 25245	16
−44.86	34	11310	+ 417	− 3179	− 2286	+ 198	+ 11562	− 10451	74
−44.72	35	11820	+ 342	− 3209	− 2173	+ 188	+ 11398	− 10268	120
−44.58	36	10290	+ 208	+ 1400	− 3338	+ 127	+ 2557	− 1956	39
−44.43	37	10800	+ 122	+ 2583	− 3235	+ 117	− 769	+ 1245	75
−43.74	38	7290	+ 59	− 620	− 2819	+ 144	+ 5893	− 5437	17
−43.60	39	7800	− 26	+ 235	− 2688	+ 135	+ 3333	− 2954	40
−43.54	135	14010	− 89	+ 3840	− 3142	+ 67	− 10020	+ 10213	121
−42.71	41	11010	− 198	+ 414	− 2435	+ 78	− 216	+ 497	76
−42.46	42	11910	− 107	+ 1033	− 1940	+ 115	− 4444	+ 4529	122
−41.90	43	13920	− 29	+ 2208	− 1814	+ 164	− 3444	+ 3291	197
−41.55	44	6840	− 452	− 2268	− 1241	− 83	+ 19576	− 19052	41
−41.30	45	7740	− 24	− 134	− 746	− 58	+ 2125	− 1989	77
−40.74	47	9750	+ 70	+ 1211	− 834	+ 40	+ 2385	− 2548	123
−40.50	50	10620	− 1	+ 1474	− 684	+ 46	+ 2224	− 2415	198
−39.98	52	6990	− 112	+ 572	− 23	+ 105	− 825	+ 485	78
−39.78	53	6300	− 88	+ 2040	− 617	+ 382	− 1816	+ 1155	43
−39.73	54	7860	− 180	+ 495	+ 129	+ 119	− 1190	+ 840	124
−39.54	55	7170	− 172	+ 2068	− 394	+ 386	− 2197	+ 1527	79
−38.62	59	11850	− 198	− 939	+ 128	+ 121	+ 2488	− 2762	199
−38.43	61	11160	− 190	+ 690	− 418	+ 391	+ 2017	− 2618	125
−37.70	62	13800	− 249	− 1767	+ 1058	+ 22	+ 3026	− 3165	200
−37.56	63	8010	− 66	− 229	− 349	+ 413	+ 7340	− 7930	80
−37.33	138	7200	− 73	+ 16	− 728	+ 445	+ 11409	− 12061	45
−36.82	65	10650	− 199	− 3067	+ 1275	+ 17	+ 8250	− 8280	126
−36.60	67	9840	− 188	− 1540	+ 3537	− 246	+ 6693	− 6667	81
−36.49	68	11850	− 97	− 3299	+ 1645	− 84	+ 3128	− 3185	201
−36.27	69	11040	+ 57	− 846	+ 4978	− 327	− 6139	+ 6044	127
−36.06	70	7890	− 368	− 953	+ 3778	− 338	− 3898	+ 3676	46
−35.79	71	14370	− 42	− 3060	+ 3750	− 260	+ 2340	− 2362	279
−35.75	72	6780	− 390	+ 3971	+ 3430	− 806	− 18612	+ 18195	23
−35.72	73	9090	− 224	+ 104	+ 5082	− 345	− 16437	+ 16004	82
−35.57	74	13560	+ 114	− 907	+ 6187	− 354	− 7816	+ 7683	202
−35.42	75	7980	− 194	+ 3215	+ 5448	− 586	− 25267	+ 24699	47
−35.02	76	11610	− 24	− 467	+ 6166	− 370	− 14184	+ 13780	128
−34.72	77	10500	+ 55	+ 709	+ 5731	− 490	− 18494	+ 18047	83
−33.66	80	6690	+ 321	− 142	+ 6262	− 453	− 16750	+ 16299	48
−29.38	140	14280	+ 333	− 516	− 2141	− 1145	− 16860	+ 16433	26
−23.79	84	7590	+ 24	+ 2495	− 4641	+ 75	− 17118	+ 16277	52
−22.90	85	10800	+ 98	+ 907	− 4495	+ 89	− 10853	+ 10294	88
−22.73	86	11400	+ 138	+ 2114	− 3170	+ 332	− 11854	+ 11043	134
−21.98	87	14130	+ 117	+ 681	− 2542	+ 108	− 9080	+ 8653	209
−21.68	88	7620	+ 526	− 1235	− 2325	+ 381	+ 7826	− 8036	89
−20.92	89	10350	+ 204	− 1488	− 1364	+ 113	+ 2547	− 2555	135
−20.78	91	10890	+ 178	− 1037	− 1180	+ 104	+ 2001	− 2023	210
−20.05	92	7200	+ 207	− 2902	− 1114	+ 121	+ 7384	− 7145	90
−19.90	93	7740	+ 183	− 2570	− 958	+ 115	+ 7014	− 6769	136
−19.88	94	14100	+ 65	− 57	− 1215	+ 101	+ 1	+ 51	288
−19.87	95	6540	+ 141	− 419	+ 439	− 63	+ 1821	− 1656	54
−19.72	96	7080	+ 212	− 968	+ 321	− 50	+ 2114	− 1876	91
−19.01	97	10950	+ 39	− 1933	− 1047	+ 115	+ 5762	− 5359	211
−18.86	99	11490	+ 17	− 1761	− 707	+ 126	+ 6311	− 5877	289
−18.82	102	10290	− 154	− 1696	− 38	− 28	+ 10128	− 9613	137
−18.68	104	10830	− 97	− 1509	+ 209	− 27	+ 8531	− 7999	212
−18.21	105	13830	+ 376	+ 15253	+ 817	+ 268	− 25040	+ 23665	357
−18.02	106	13170	+ 731	+ 14967	+ 2246	+ 51	− 31410	+ 30275	290
−17.94	108	7110	− 356	− 4818	+ 3	+ 5	+ 22396	− 21280	92
−17.79	109	7650	− 148	− 3963	+ 241	− 7	+ 16509	− 15489	138
−17.78	110	6540	− 394	− 5145	+ 159	− 11	+ 24350	− 23116	56
−17.63	111	7080	− 111	− 3673	+ 406	− 24	+ 15816	− 14762	93
0 −17.14	112	9990	+ 899	+ 13260	+ 2454	+ 41	− 25950	+ 24993	213
0 −16.98	114	9420	+ 1078	+ 13274	+ 2838	+ 14	− 26709	+ 25784	139
0 −16.29	118	6930	+ 3765	+ 13011	− 2546	− 117	+ 67321	− 67953	94
0 −16.15	142	6420	+ 6503	− 5443	− 45459	− 3917	+ 582192	− 576844	58

Table 8b

Residuals of Solution II for Orbits of Table 6b.

t	Orbit	Half-arc length	$\delta a \cdot 10^7$	$\delta e \cdot 10^8$	$\delta I \cdot 10^6$	$\delta\Omega \cdot 10^5$	$\delta\omega \cdot 10^5$	$\delta M \cdot 10^5$	Ser. no. of arc
$-48^h.48$	25	3810^s	- 260	+ 1188	- 2617	+ 26	- 2123	+ 3352	14
-43.74	38	7290	+ 268	- 645	- 1511	+ 15	+ 8014	- 8067	17
-40.34	51	4290	- 136	- 556	+ 1128	+ 17	- 3019	+ 2473	19
-36.79	139	5250	- 160	- 1163	+ 652	+ 194	+ 9630	- 10332	22
-32.88	81	3900	+ 538	- 191	+ 7369	- 393	- 12516	+ 11918	25
-23.79	84	7590	- 130	+ 3305	- 4870	+ 105	- 13882	+ 13403	52
-18.83	100	3900	- 108	- 1936	- 147	+ 36	+ 13896	- 12747	55
0-15.22	143	3060	+ 31951	- 33254	+ 4897	- 6104	+ 256803	- 251671	32

Table 8c

Residuals of Solution III for Orbits of Table 6c.

t	Orbit	Half-arc length	$\delta a \cdot 10^7$	$\delta e \cdot 10^8$	$\delta I \cdot 10^6$	$\delta\Omega \cdot 10^5$	$\delta\omega \cdot 10^5$	$\delta M \cdot 10^5$	Ser. no. of arc
0 $-96^h.81$	169	7650^s	- 1363	+ 16485	- 3991	+ 354	- 802	- 6854	564
0 -68.22	170	3960	- 61	- 16817	- 1049	- 1084	+ 43702	- 42262	565
0 -62.54	171	3090	+ 1482	+ 2468	+ 2708	+ 243	+ 20412	- 21851	566
-48.48	25	3810	- 407	+ 399	- 2862	+ 139	+ 1248	- 1220	14
0 -46.79	131	4350	+ 19640	+ 22582	+ 2786	+ 124	+ 3462	- 9697	15
0 -44.49	172	4590	+ 936	- 4940	- 1564	+ 223	+ 40349	- 40076	567
-42.44	173	3630	+ 404	+ 891	+ 2	- 222	+ 6961	- 6919	568
-40.53	49	4980	- 309	- 1697	+ 1255	- 123	+ 919	- 776	42
-38.67	58	4020	+ 271	+ 763	+ 1076	+ 254	+ 8898	- 9001	44
-36.48	174	4140	- 452	+ 3261	+ 2986	+ 370	- 15887	+ 15439	569
0 -34.36	79	4170	+ 282	+ 2014	+ 7073	- 756	- 15938	+ 16524	24
-23.79	84	7590	+ 175	+ 3384	- 3992	- 169	- 17825	+ 17617	52
-20.81	141	4470	+ 715	- 2109	- 1673	+ 126	+ 12293	- 12174	53
-18.83	100	3900	+ 288	- 1683	+ 956	- 317	+ 5709	- 5452	55
-16.94	116	4590	- 456	- 4213	+ 1833	- 256	- 5557	+ 5975	57
0 -15.22	143	3060	+ 32412	- 32873	+ 6165	- 6514	+ 244944	- 241859	32
0 - 0.28	180	7140	+ 354	- 11247	- 8620	- 594	+ 65259	- 63740	570
0 +11.62	181	8730	+ 649	- 1033	- 598	+ 814	+ 13887	- 15119	571
+31.72	177	8130	- 170	- 167	+ 1664	+ 173	+ 1741	- 2250	572
+33.40	178	7740	- 153	- 1515	+ 954	+ 209	+ 9042	- 9195	573
+46.98	179	7140	+ 125	+ 2689	- 2186	- 182	- 7543	+ 7955	574

Table 9a

Comparison of Probable Errors of the Elements for the Arcs of Tables 6a and 4b (Short and Long Arcs Respectively).

	$S_1 \cdot 10^7$	$S_2 \cdot 10^8$	$S_3 \cdot 10^6$	$S_4 \cdot 10^5$	$S_5 \cdot 10^5$	$S_6 \cdot 10^5$
	Short arcs					
Mean	145	869	522	70	3466	3402
Min.	22	320	150	25	1427	1392
Max.	1472	2235	2974	356	19717	19375
Range	1450	1915	2824	331	18290	17983
Mean of Min, Max.	747	1278	1562	190	10572	10384
	Long arcs					
Mean	15	963	646	102	3847	3776
Min.	8	735	535	69	3239	3178
Max.	17	1383	820	140	4128	4069
Range	9	648	285	71	889	891
Mean of Min, Max.	12	1059	678	104	3684	3624

Table 9b

Comparison of Probable Errors of Representation for the Arcs of Tables 6a and 4b (Short and Long Arcs Respectively).

	$\cos \delta \; \Delta\alpha$	$\Delta\delta$
	Short arcs	
Mean	0°.00521	0°.00551
Min.	0.00142	0.00141
Max.	0.02160	0.02610
Range	0.02018	0.02469
Mean of Min, Max.	0.01151	0.01376
	Long arcs	
Mean	0°.00849	0°.00908
Min.	0.00316	0.00604
Max.	0.01301	0.01306
Range	0.00985	0.00702
Mean of Min, Max.	0.00808	0.00955

Table 10a

Range in Mean Anomalies of Observations Considered in Deriving Elements for the 21 Arcs of Table 6c.

t	Orbit	Min. M	Max. M	Range
$-96^h.81$	169 *	305°	70°	125°
-68.22	170 *	25	90	65
-62.54	171 *	305	130	185
-48.48	25	320	65	105
-46.79	131 *	320	65	105
-44.49	172 *	10	110	100
-42.44	173	350	110	120
-40.53	49	350	130	140
-38.67	58	300	135	195
-36.48	174	55	110	55
-34.36	79 *	0	120	120
-23.79	84	20	120	100
-20.81	141	15	110	95
-18.83	100	355	110	115
-16.94	116	0	105	105
-15.22	143 *	290	100	170
- 0.28	180 *	0	60	60
+11.62	181 *	330	155	185
+31.72	177	35	170	135
+33.40	178	35	175	140
+46.98	179	0	55	55

*Omitted in Solution III.

Table 10b

Range in Mean Anomalies of Observations Considered in Deriving Elements for the Long Arcs of Table 4b.

t	Orbit	Min. M	Max. M	Range
$-60^h.00$	182	305°	130°	185°
-36.00	183	300	140	200
-12.00	184	295	110	175
+12.00	185	325	155	190
+36.00	186	10	175	165

Figure 1 (a through f)—Probable errors of the S_i versus half-arc length.

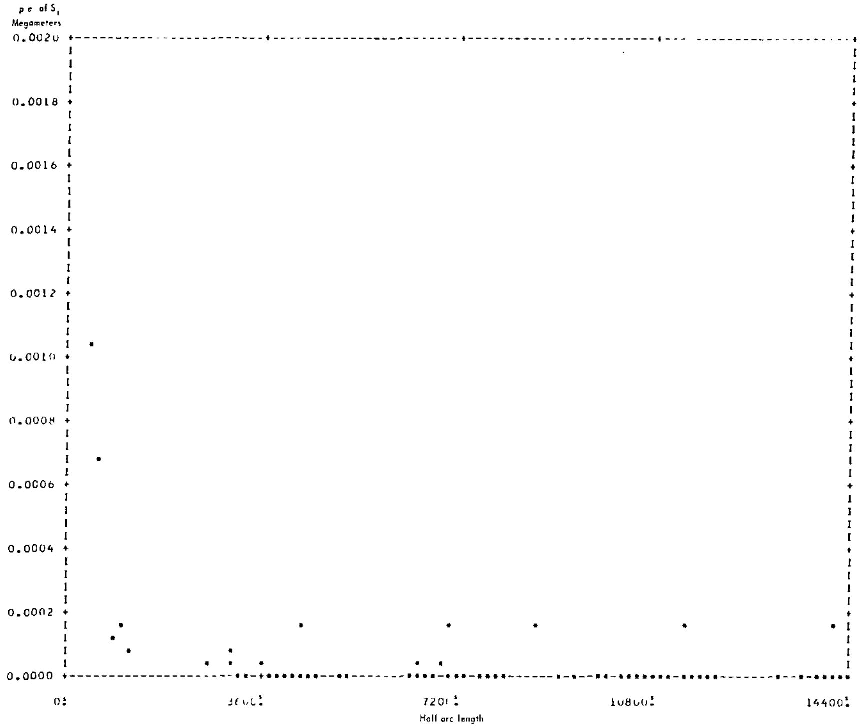

Figure 1a. Probable error of S_1 (megameters)

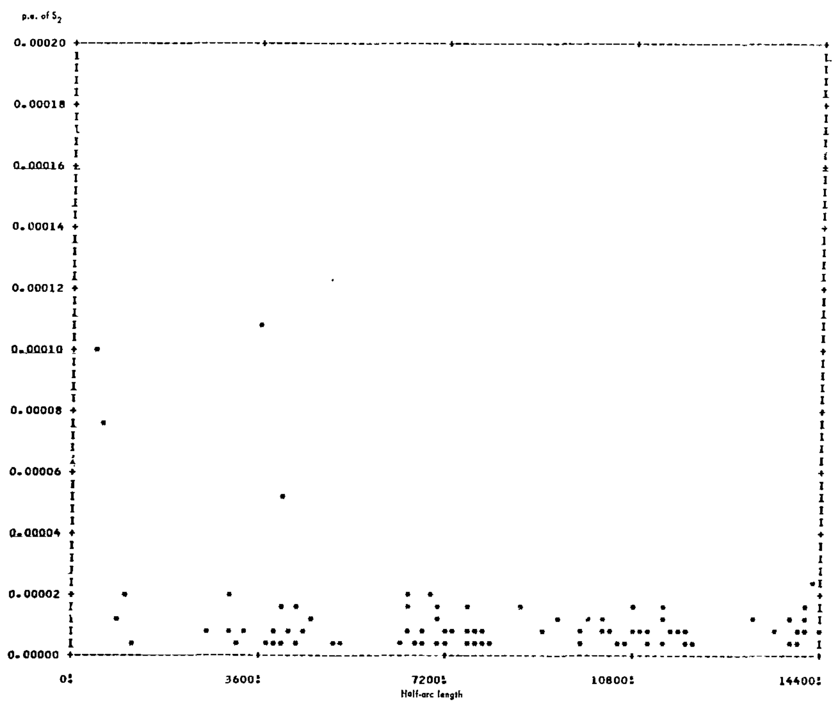

Figure 1b. Probable error of S_2

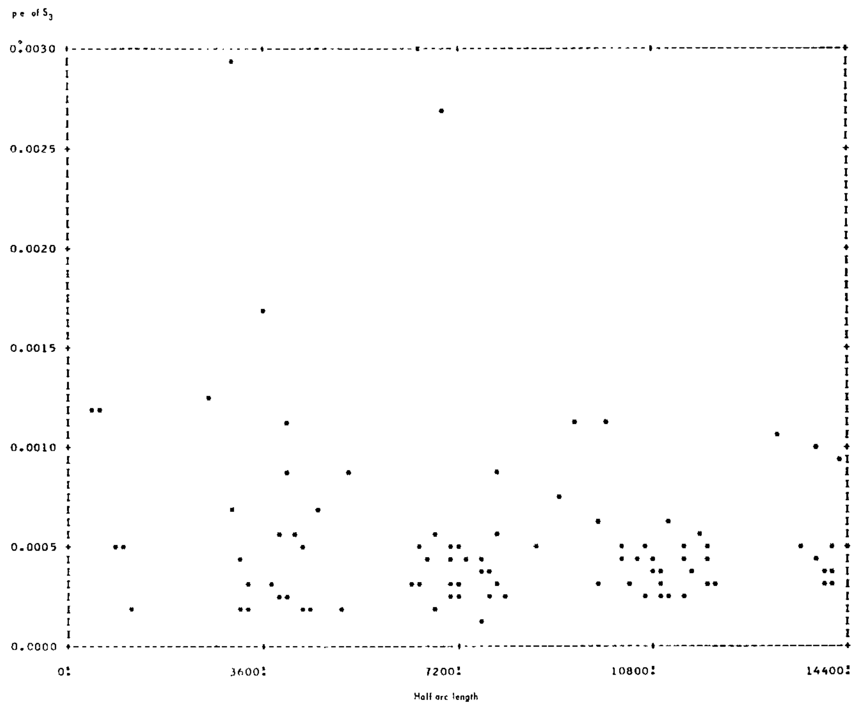

Figure 1c. Probable error of S_3 (degrees)

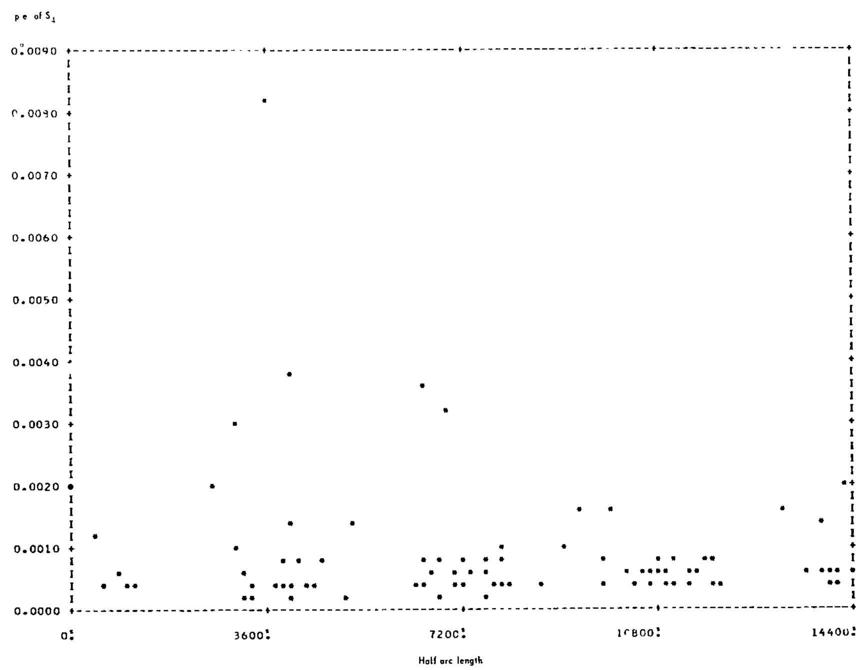

Figure 1d. Probable error of S_4 (degrees)

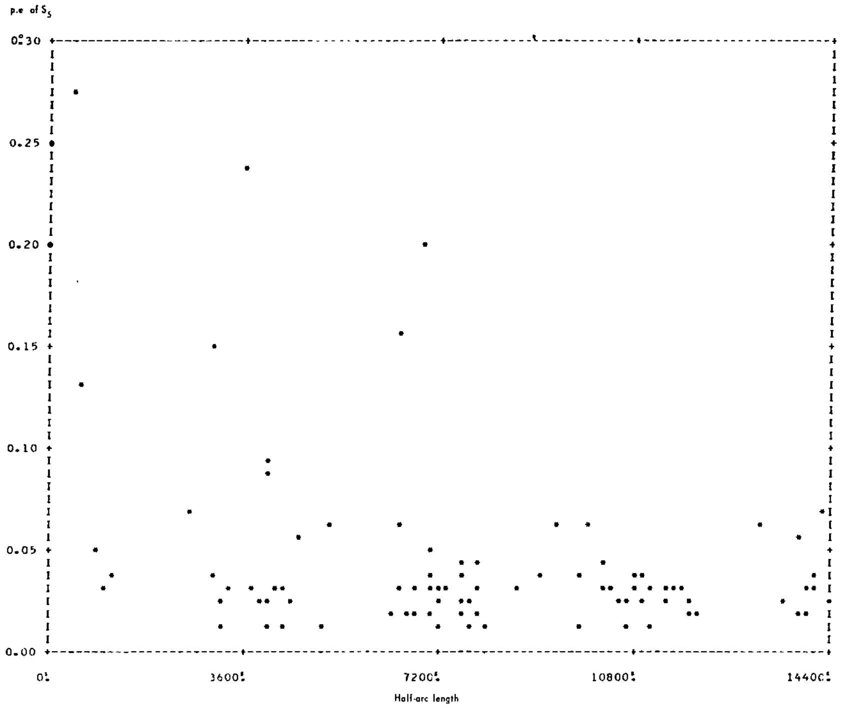

Figure 1e. Probable error of S_5 (degrees)

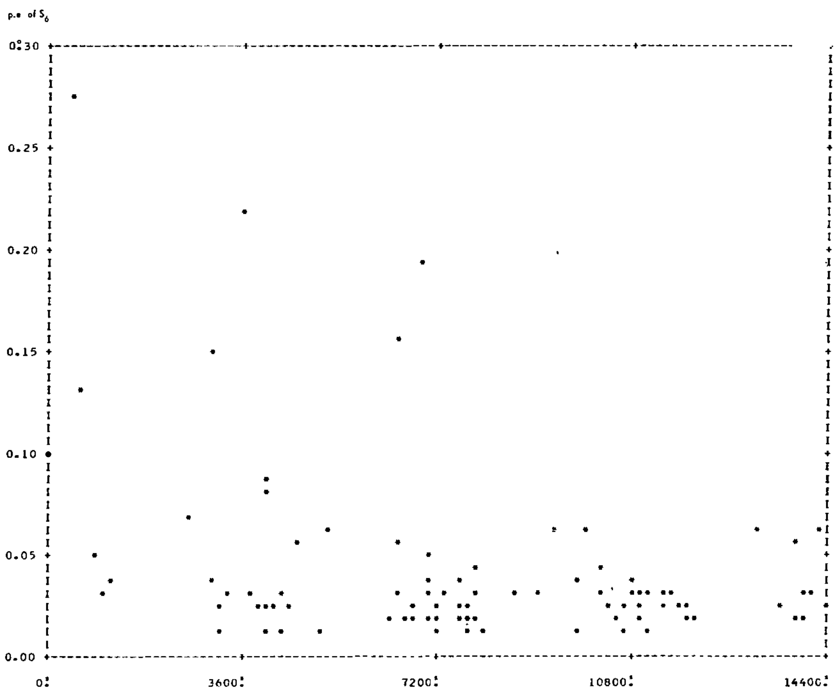

Figure 1f. Probable error of S_6 (degrees)

Figure 2(a through f)—S_1, S_2, S_3, $\Delta\Omega$, $\Delta\omega$, ΔM versus t (68 orbits corresponding to Table 6a).

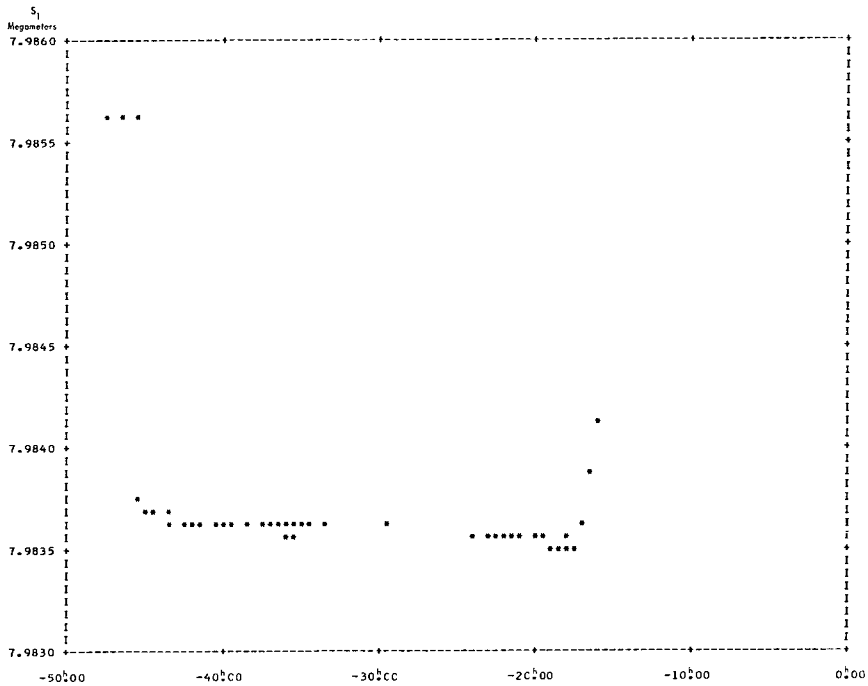

Figure 2a. Values of S_1 (megameters)

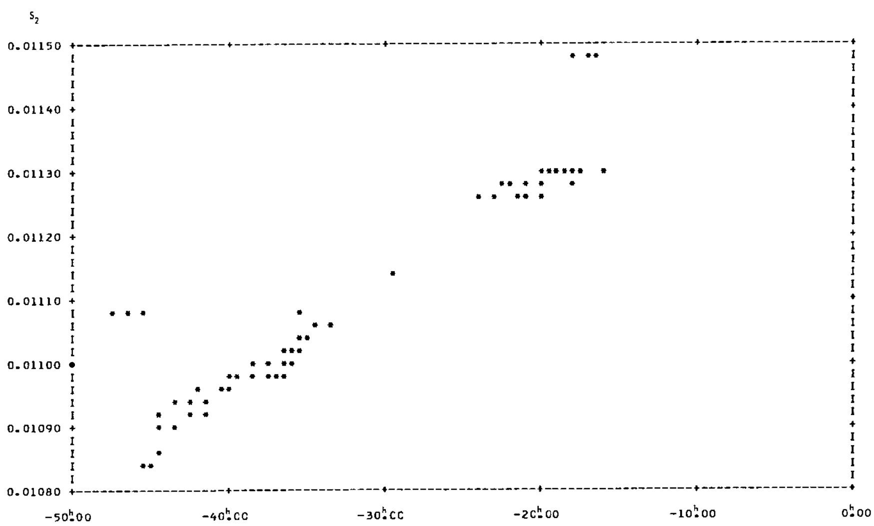

Figure 2b. Values of S_2

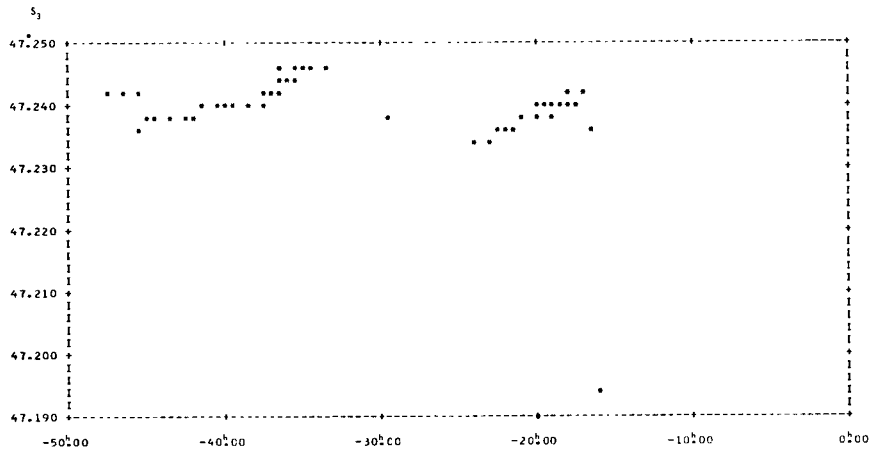

Figure 2c. Values of S_3 (degrees)

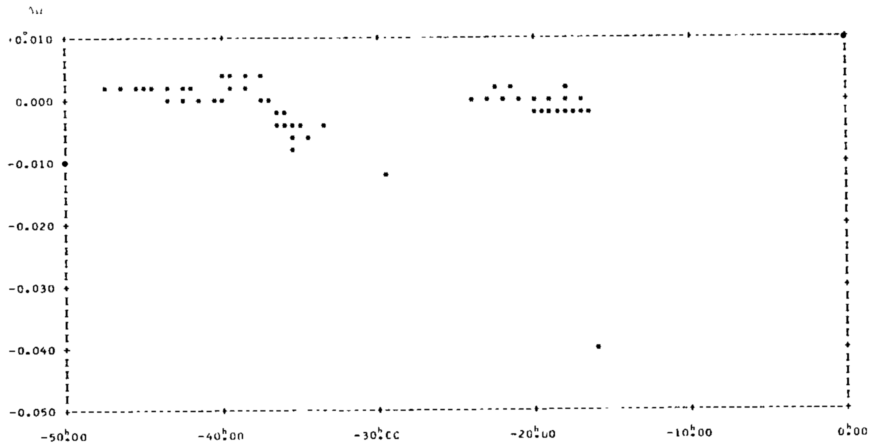

Figure 2d. Values of $\Delta\Omega$ (degrees)

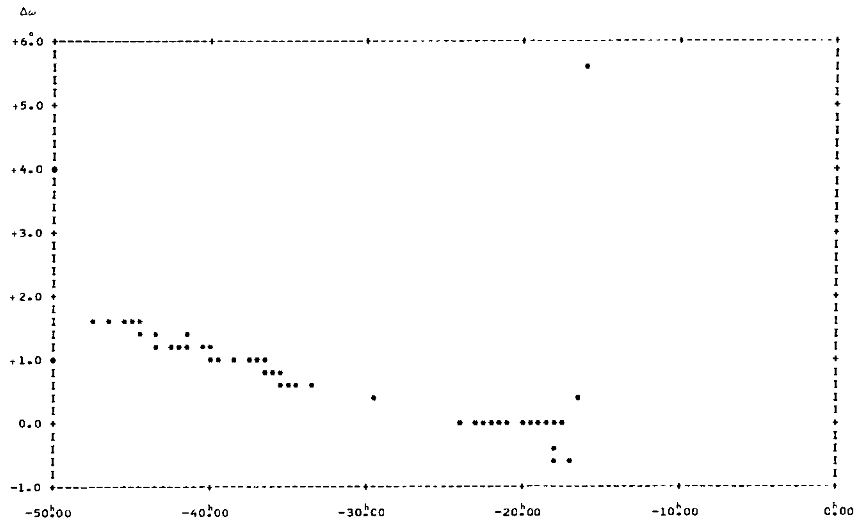

Figure 2e. Values of Δω (degrees)

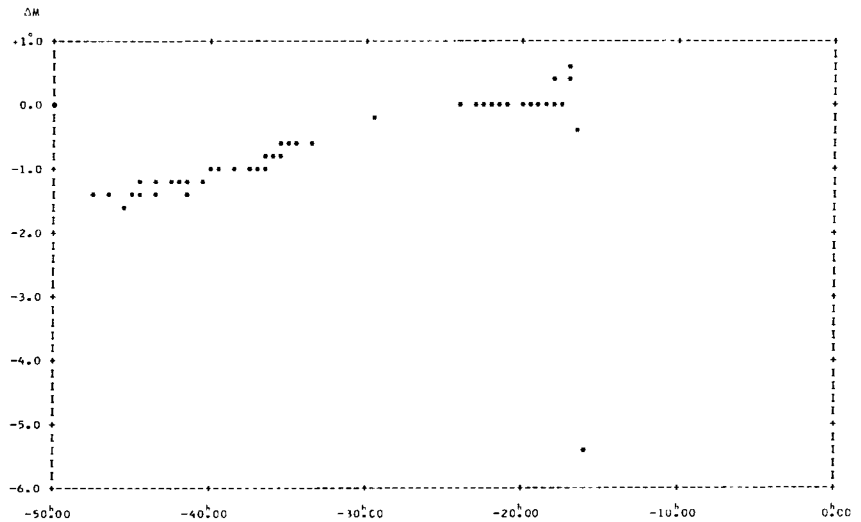

Figure 2f. Values of ΔM (degrees)

Figure 3 (a through f)—δa, δe, δI, $\delta \Omega$, $\delta \omega$, δM versus t (68 orbits corresponding to Table 6a).

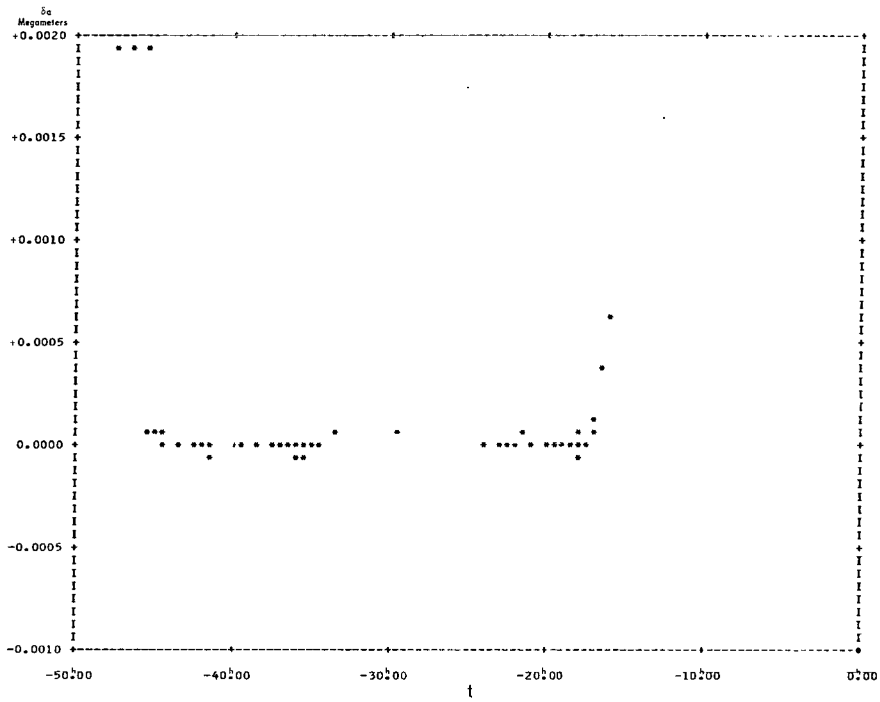

Figure 3a. Values of δa (megameters)

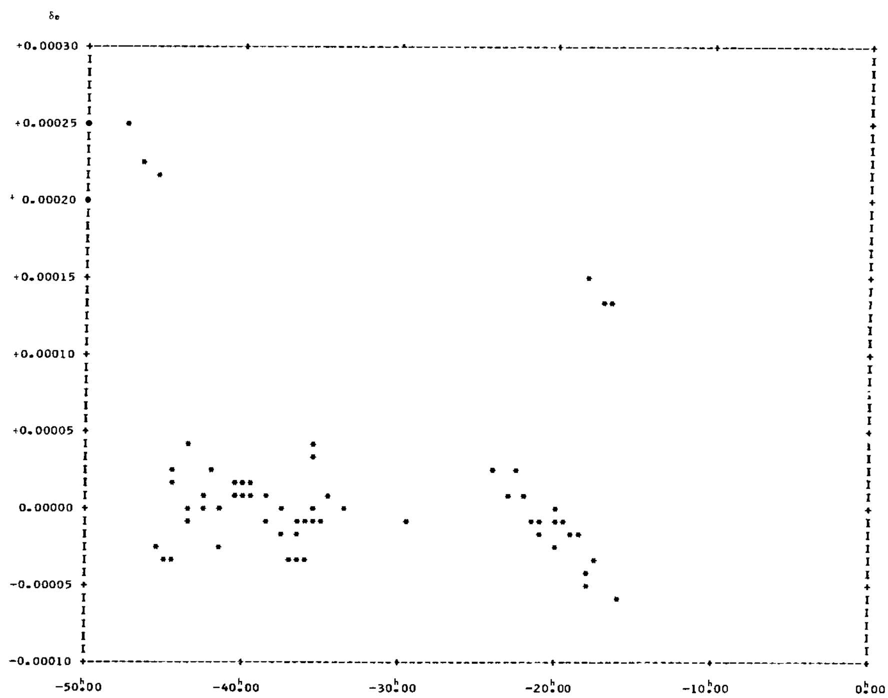

Figure 3b. Values or δe.

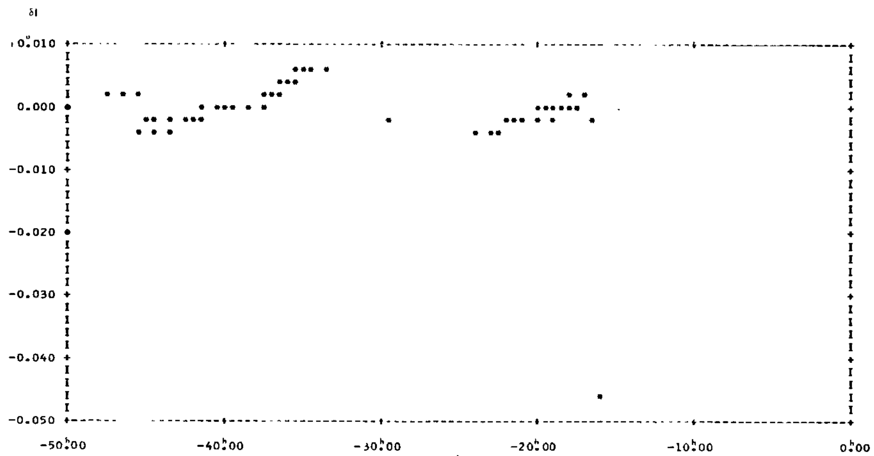

Figure 3c. Values of δI (degrees)

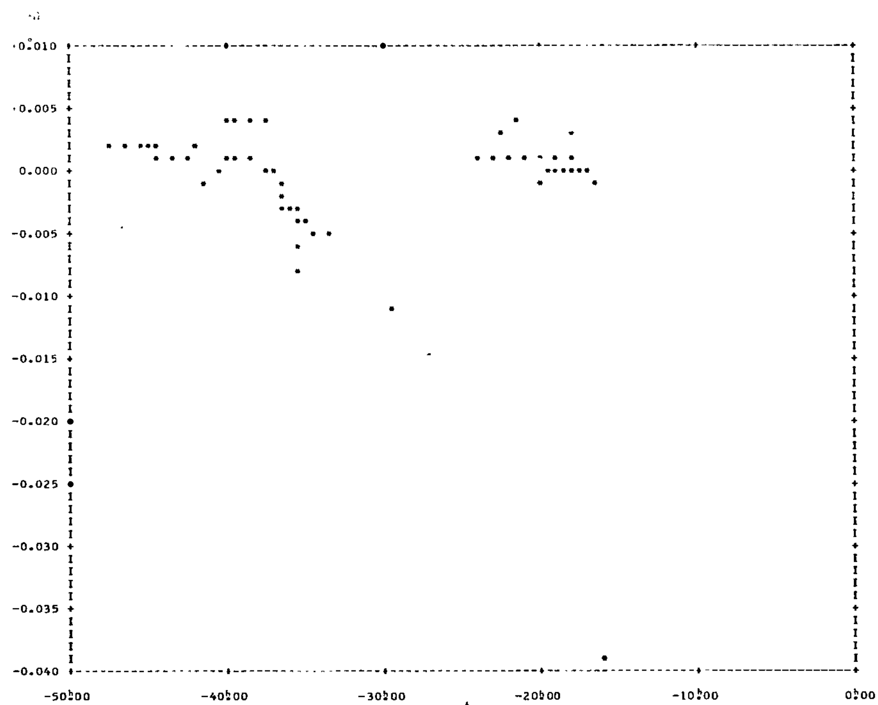

Figure 3d. Values of δΩ (degrees)

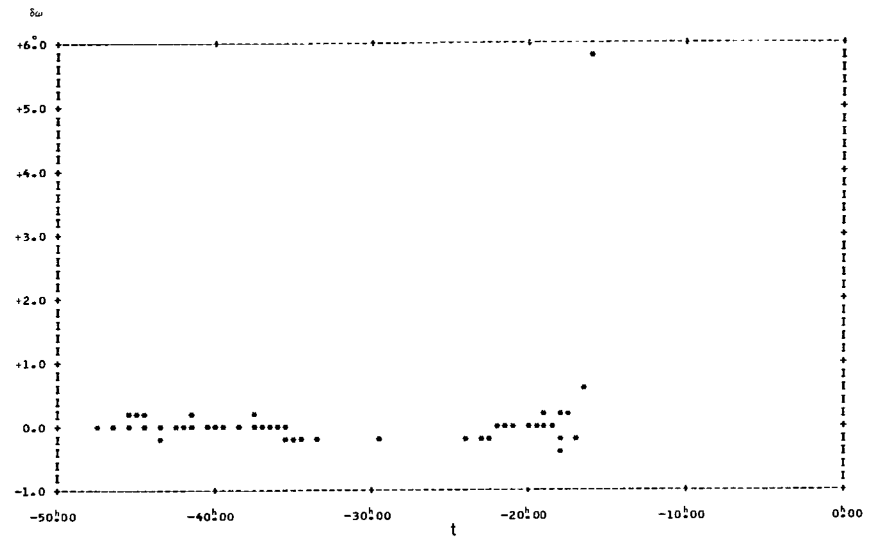

Figure 3e. Values of δω (degrees)

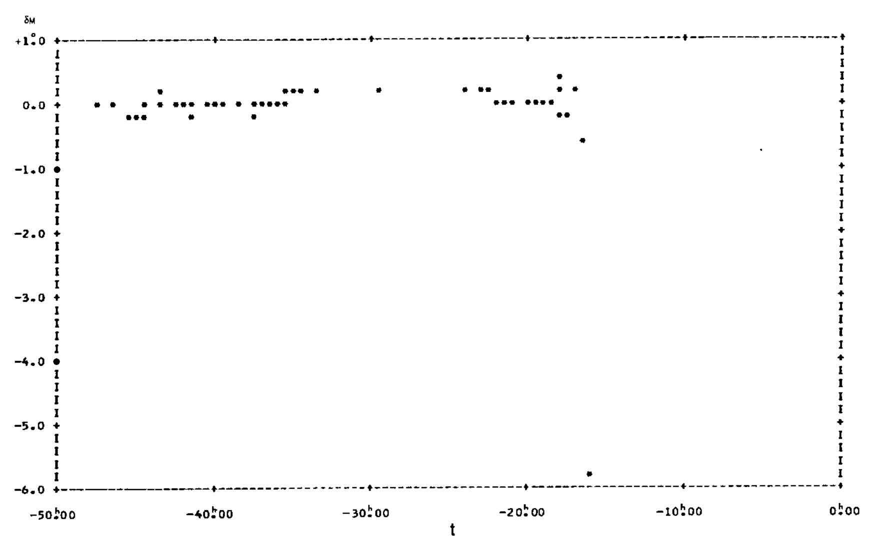

Figure 3f. Values of δM (degrees)

Figure 4 (a through f)—S_1, S_2, S_3, $\Delta\Omega$, $\Delta\omega$, ΔM versus t (8 orbits corresponding to Table 6b).

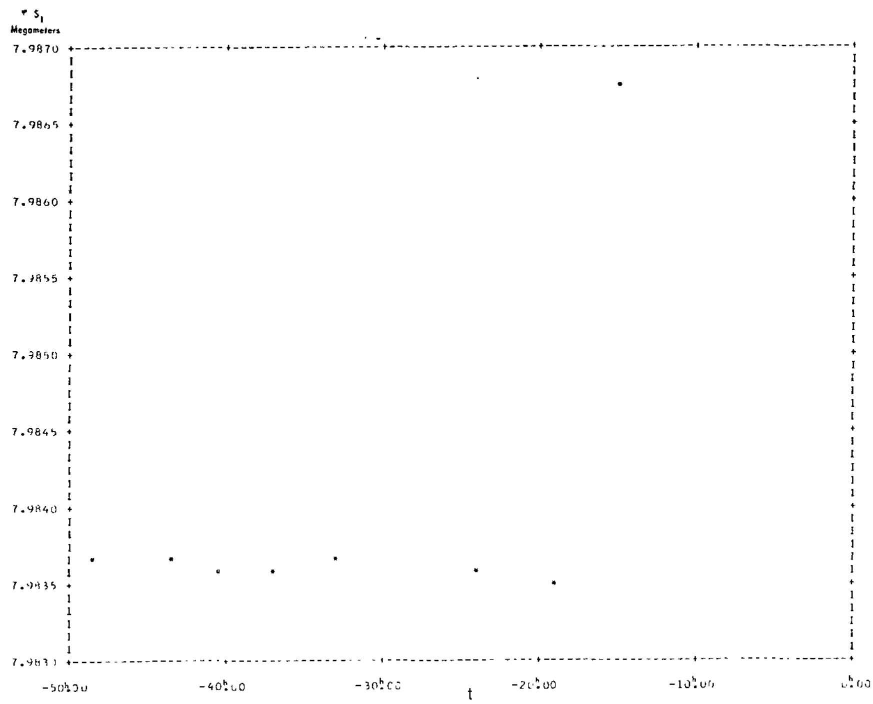

Figure 4a. Values of S_1 (megameters)

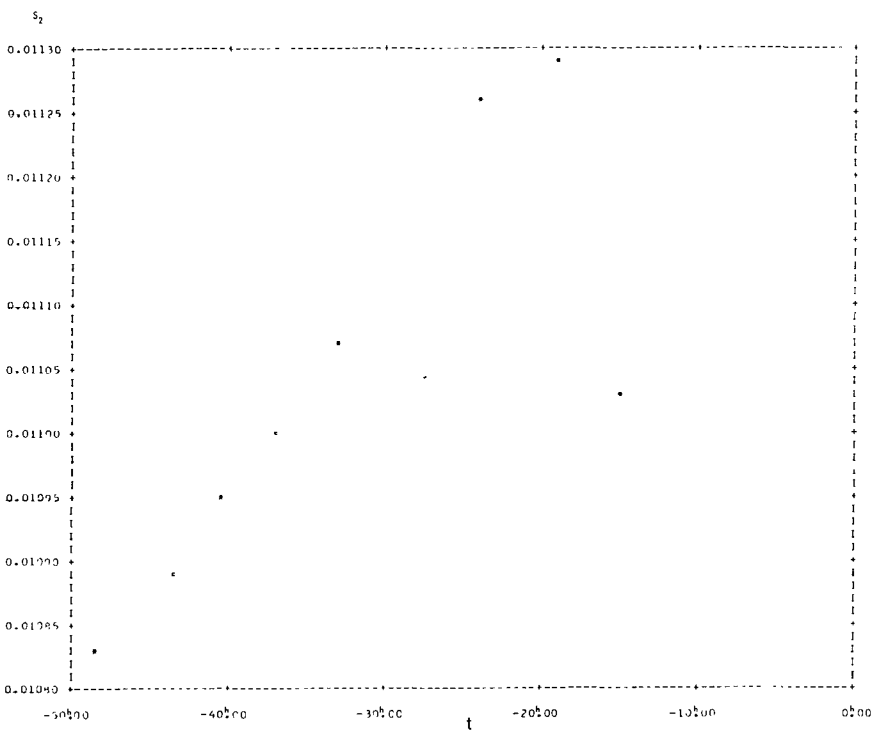

Figure 4b. Values of S_2

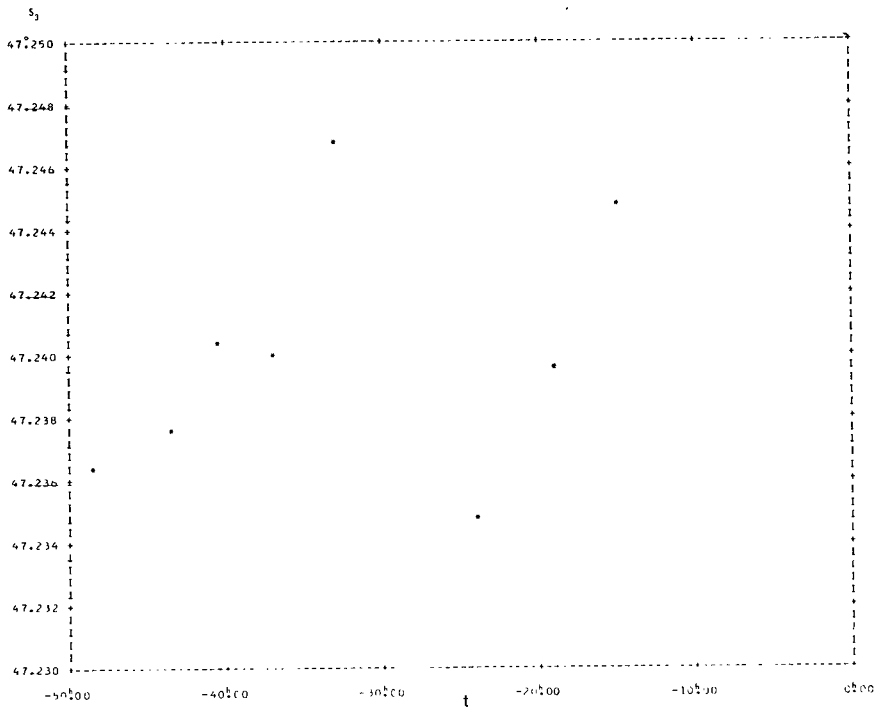

Figure 4c. Values of S_3 (degrees)

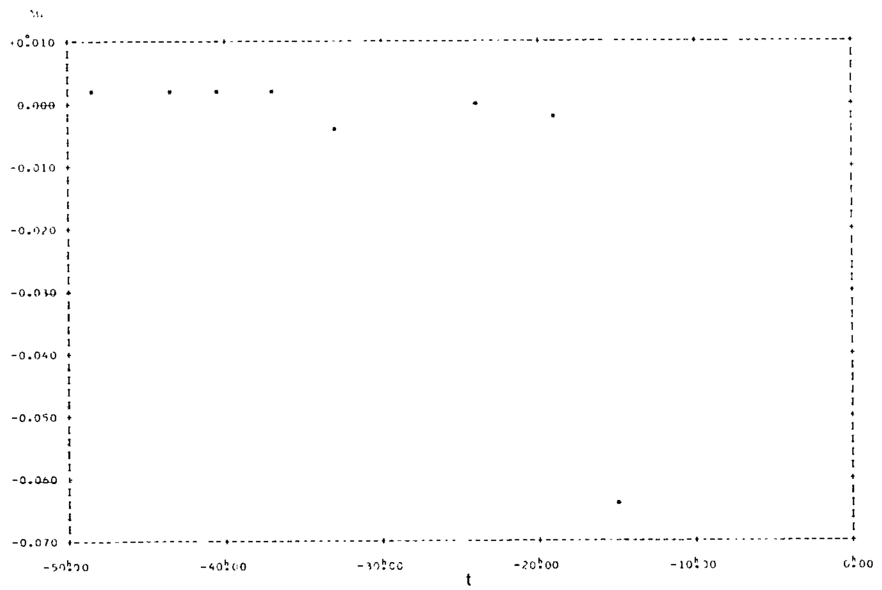

Figure 4d. Values of Ω (degrees)

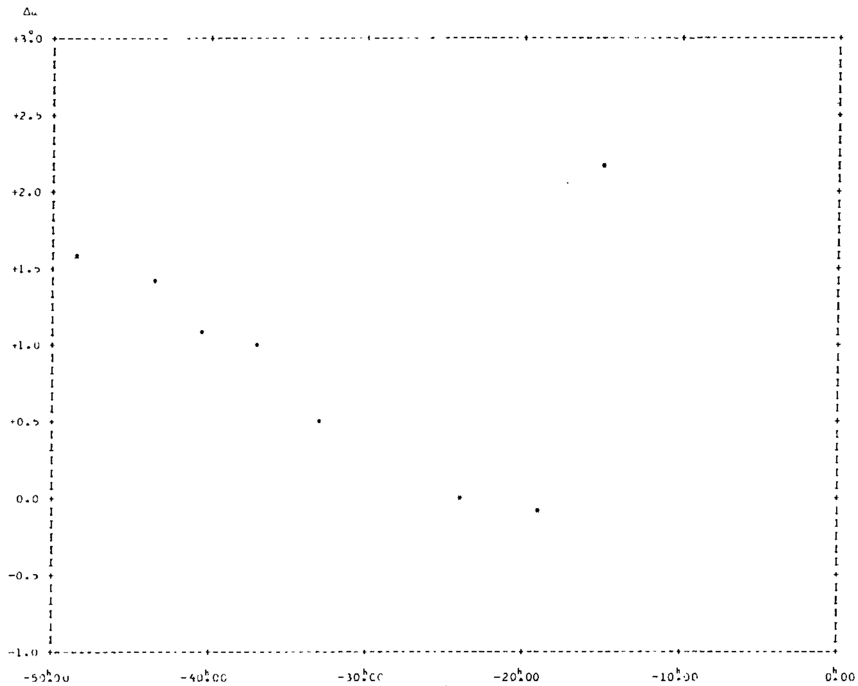

Figure 4e. Values of Δω (degrees)

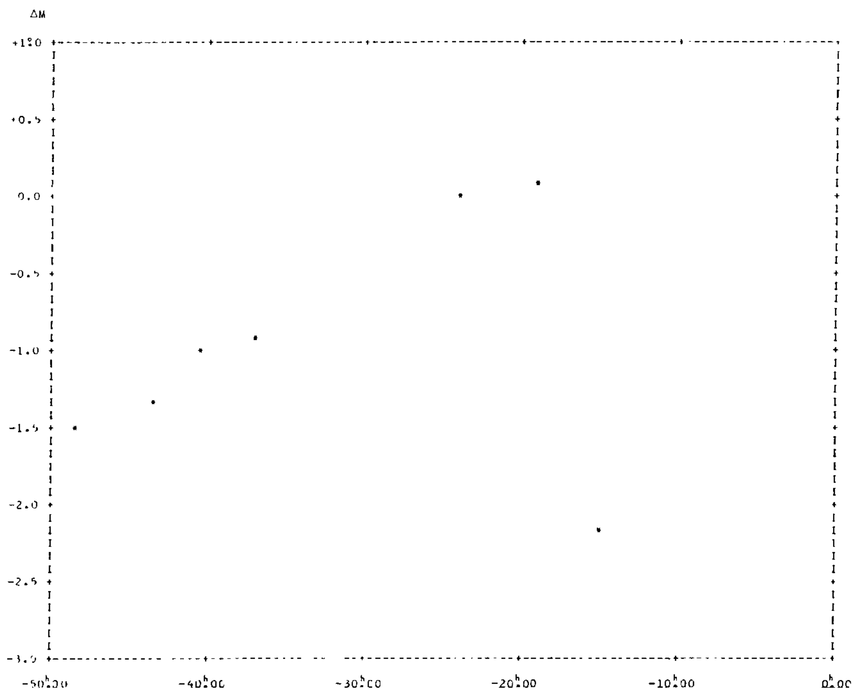

Figure 4f. Values of ΔM (degrees)

Figure 5 (a through f)—δa, δe, δI, $\delta \Omega$, $\delta \omega$, δM versus t (8 orbits corresponding to Table 6b).

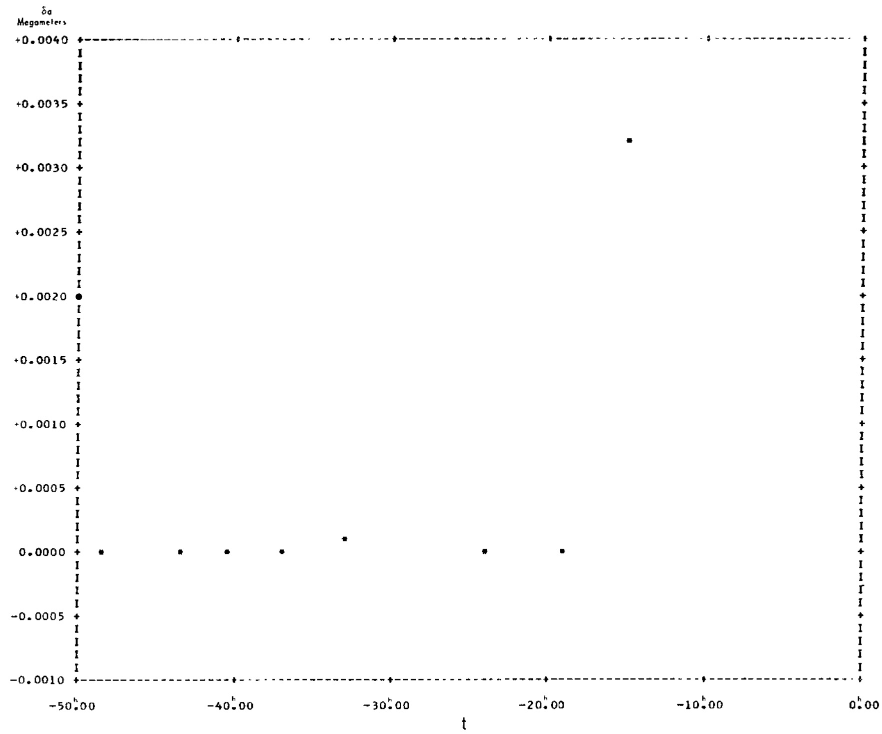

Figure 5a. Values of δa (megameters)

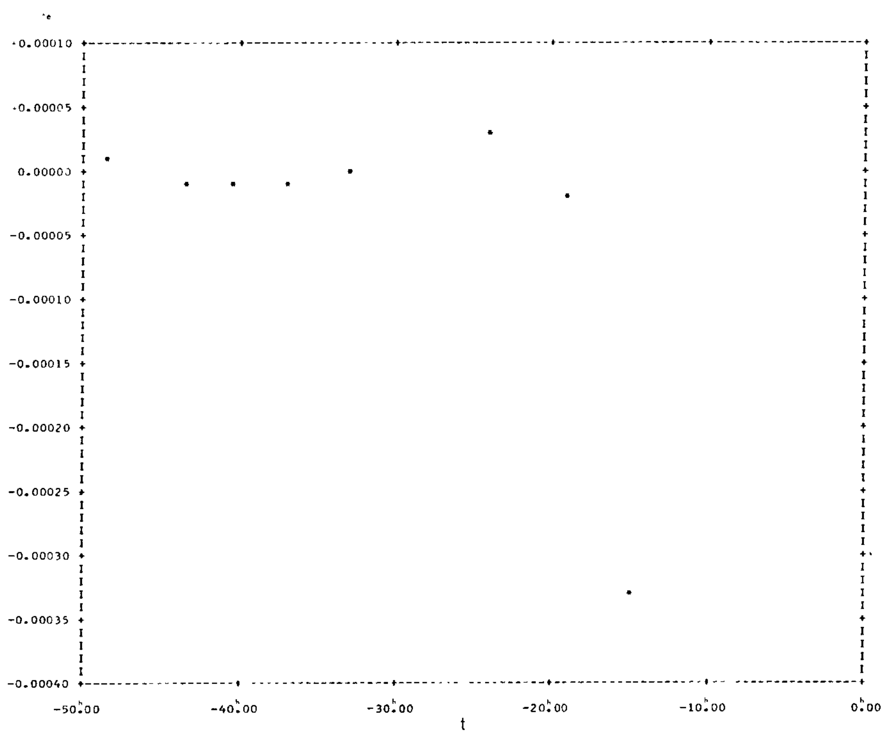

Figure 5b. Values of δe

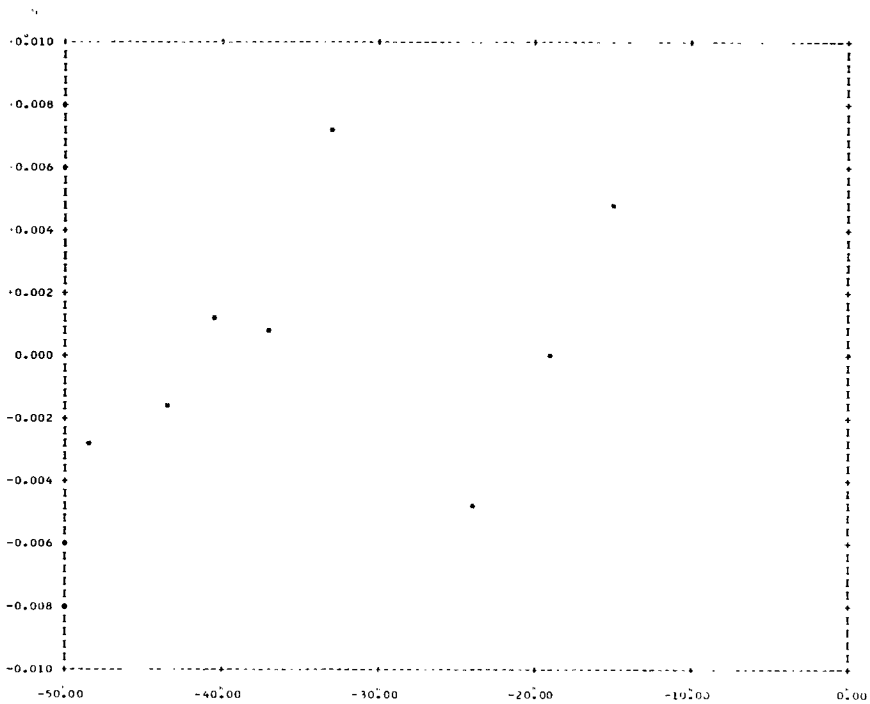

Figure 5c. Values of δI (degrees)

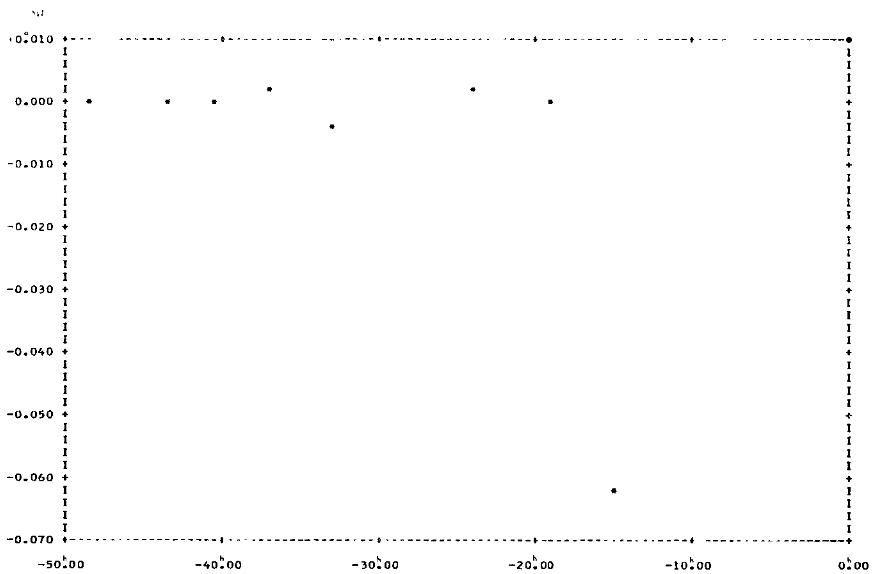

Figure 5d. Values of δΩ (degrees)

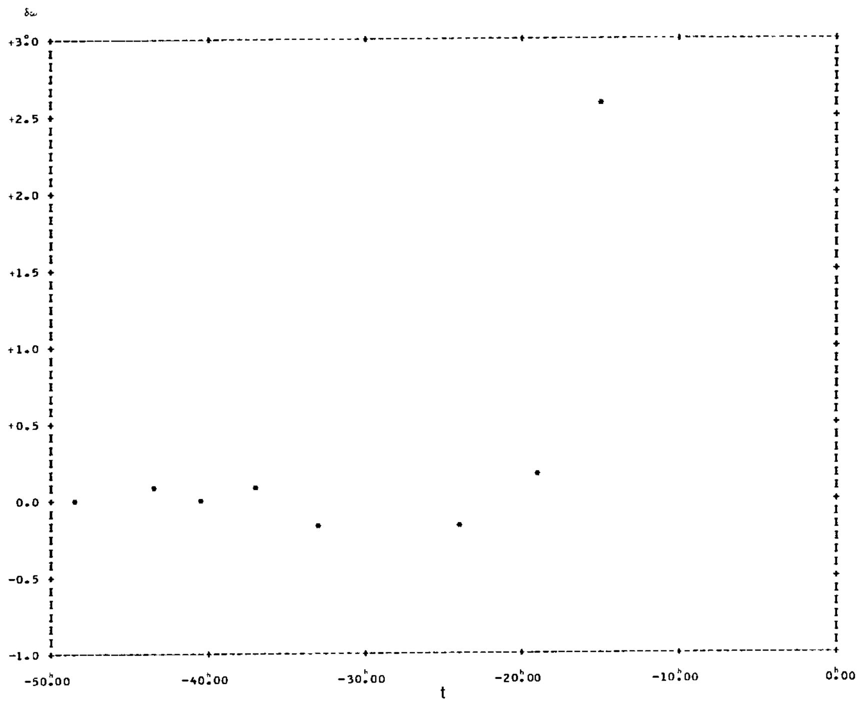

Figure 5e. Values of δω (degrees)

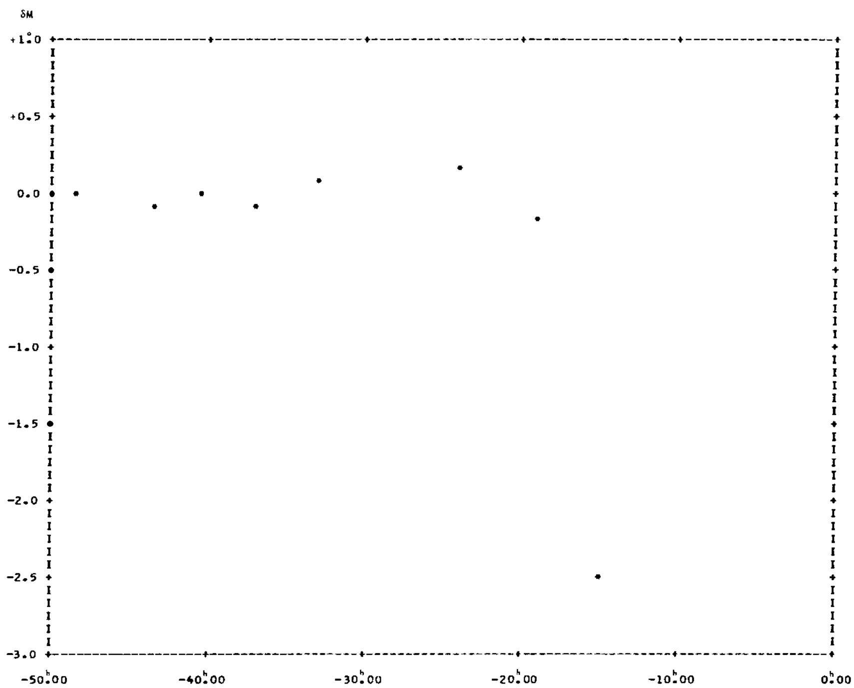

Figure 5f. Values of δM (degrees)

Figure 6 (a through f)—S_1, S_2, S_3, $\Delta\Omega$, $\Delta\omega$, ΔM versus t (21 orbits corresponding to Table 6c).

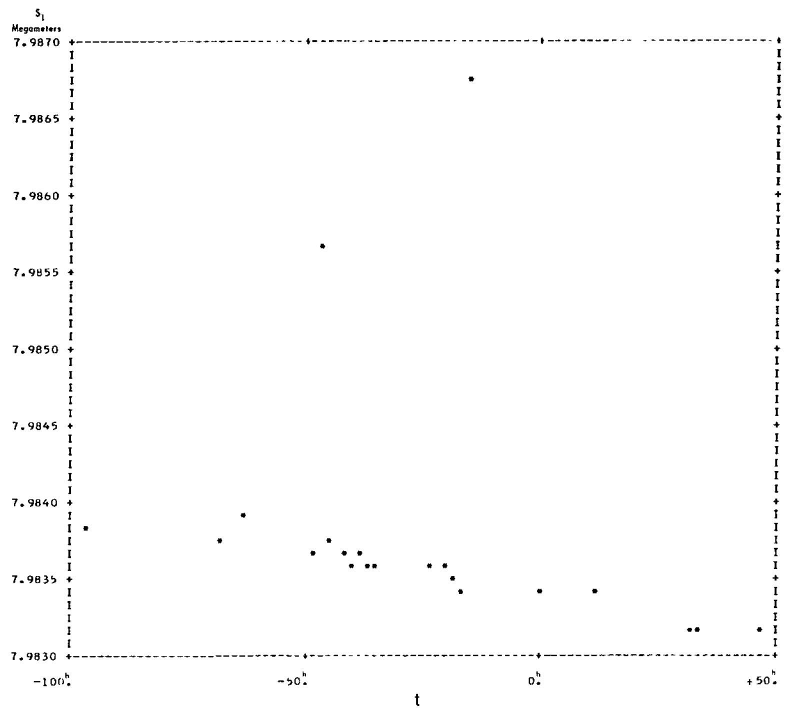

Figure 6a. Values of S_1 (megameters)

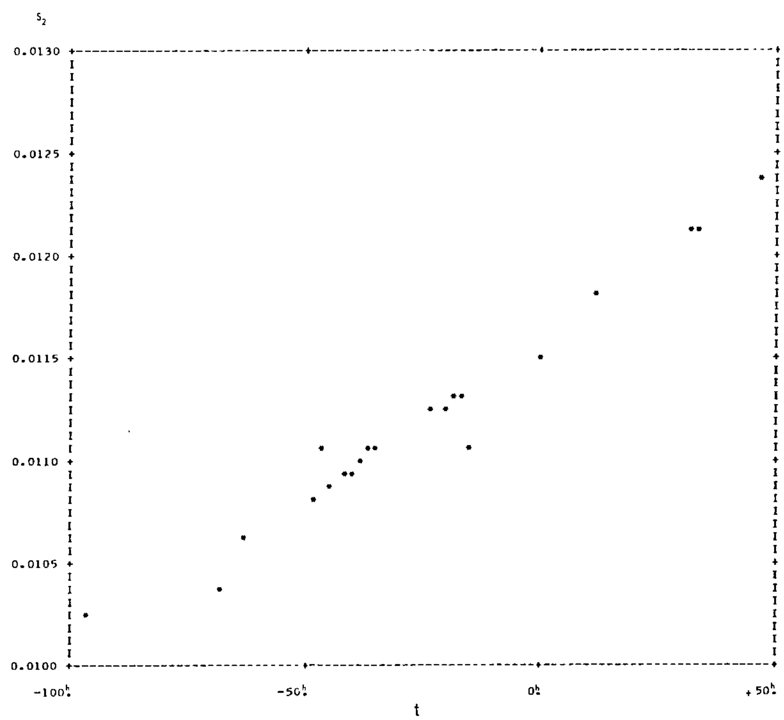

Figure 6b. Values of S_2

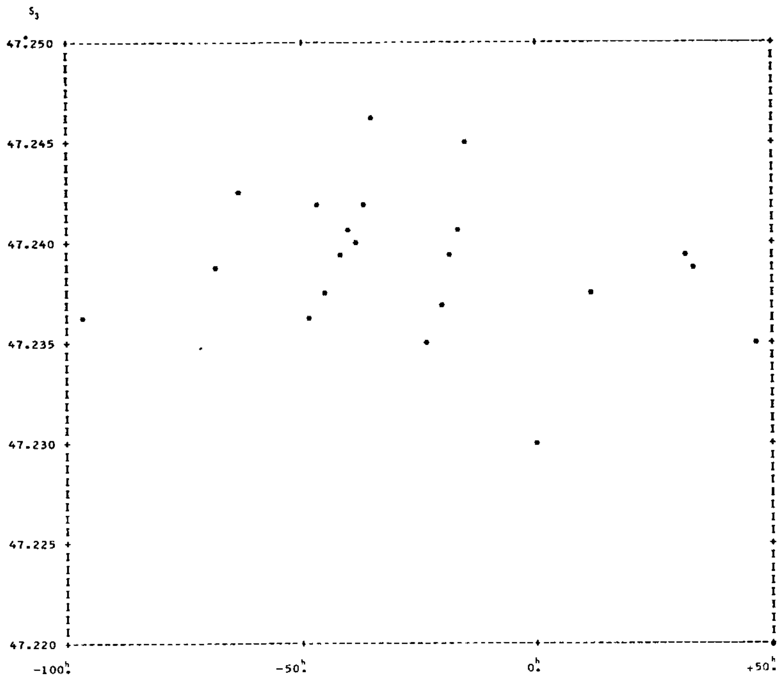

Figure 6c. Values of S_3 (degrees)

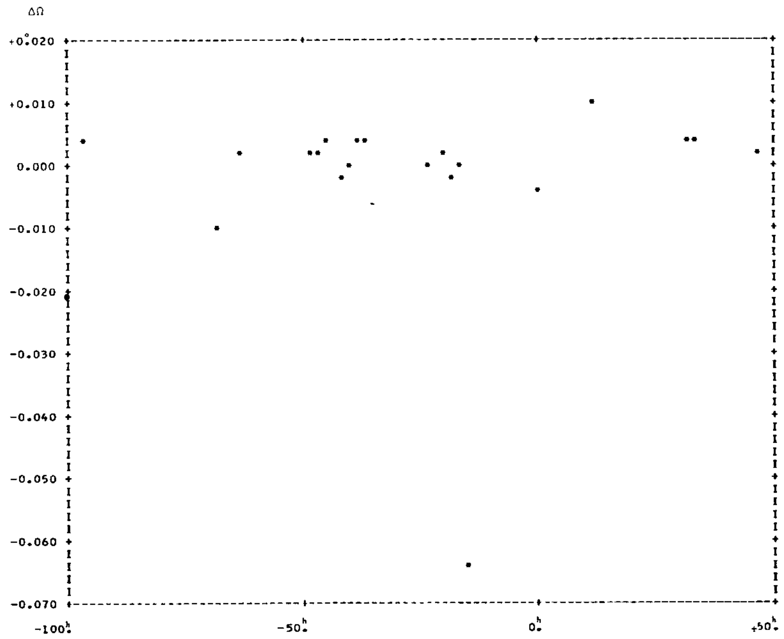

Figure 6d. Values of $\Delta\Omega$ (degrees)

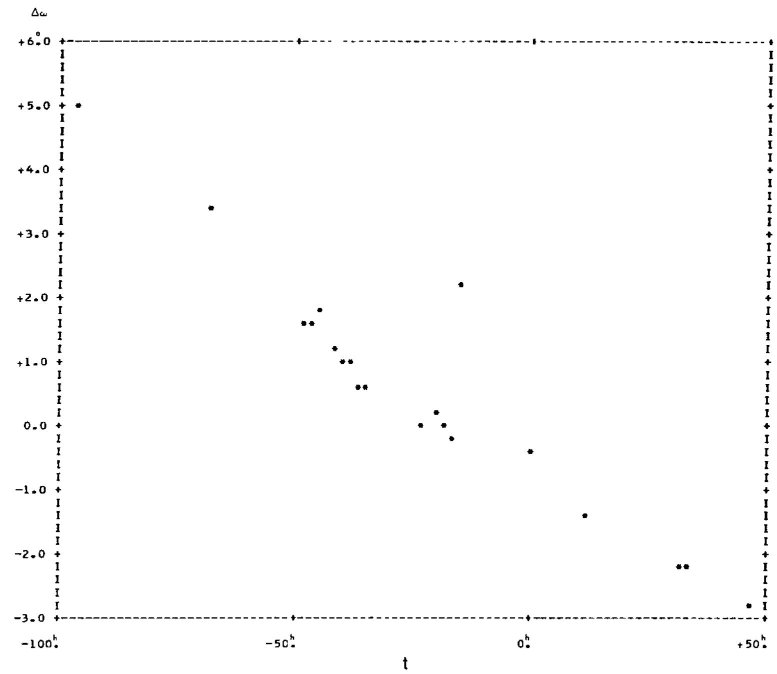

Figure 6e. Values of Δω (degrees)

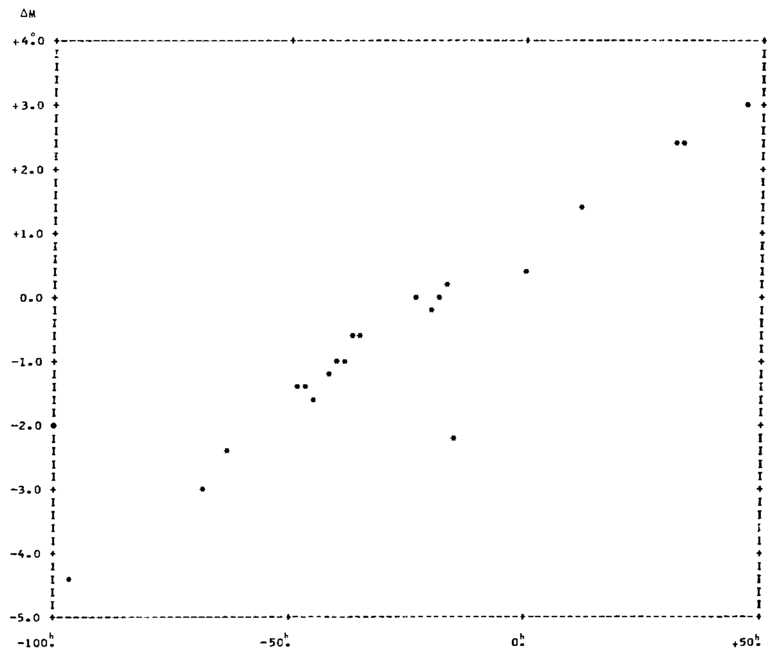

Figure 6f. Values of ΔM (degrees)

Figure 7 (a through f)—δa, δe, δI, $\delta \Omega$, $\delta \omega$, δM versus t (21 orbits corresponding to Table 6c).

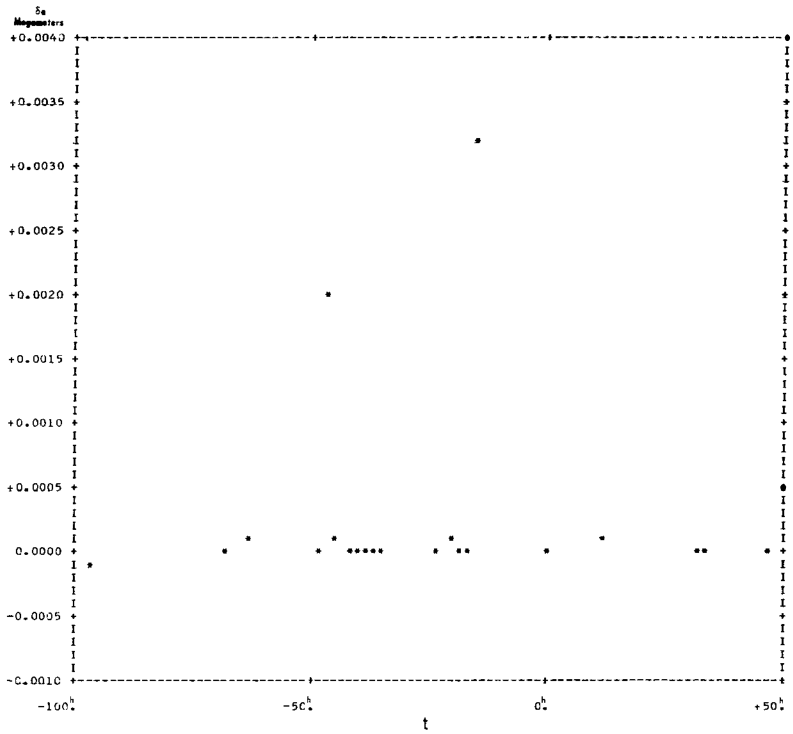

Figure 7a. Values of δa (megameters)

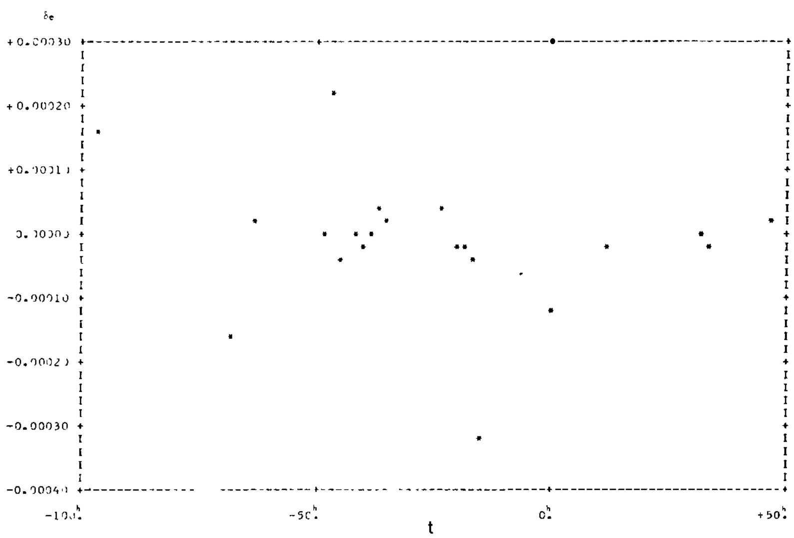

Figure 7b. Values of δe

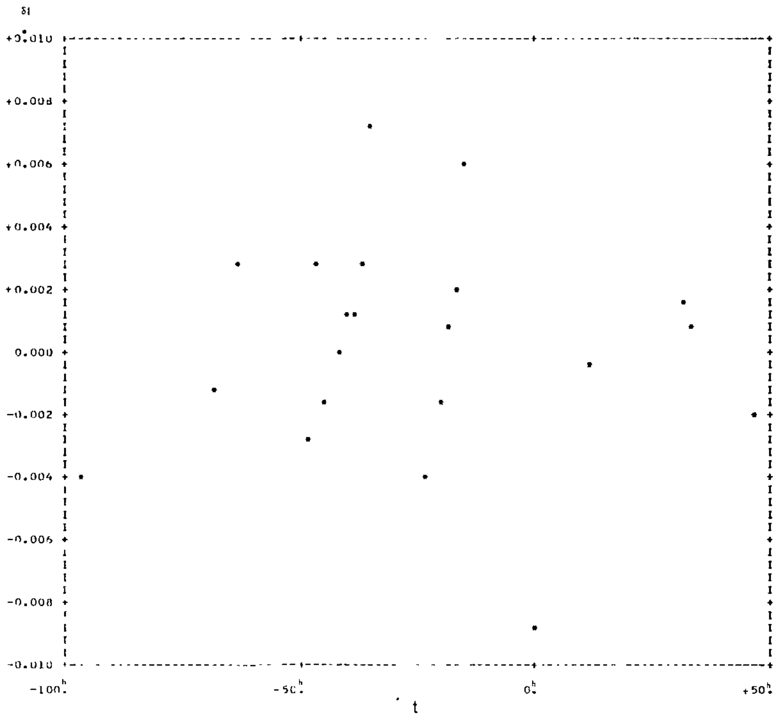

Figure 7c. Values of δI (degrees)

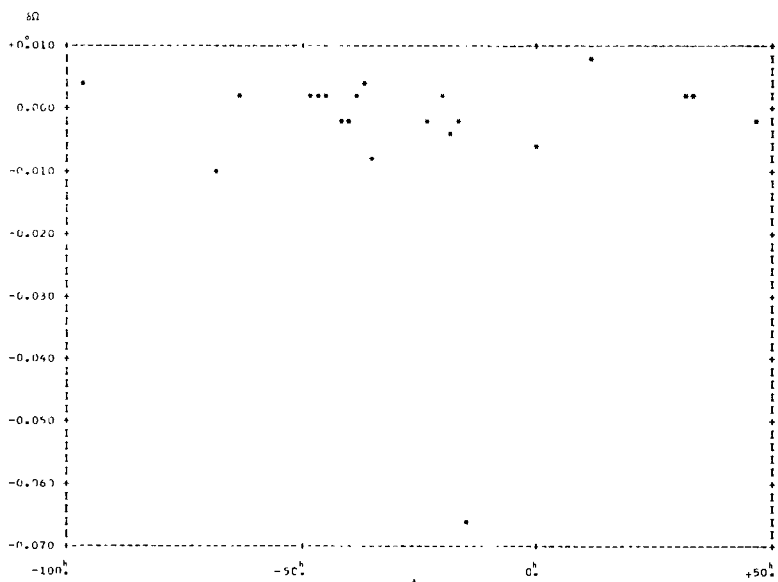

Figure 7d. Values of δΩ (degrees)

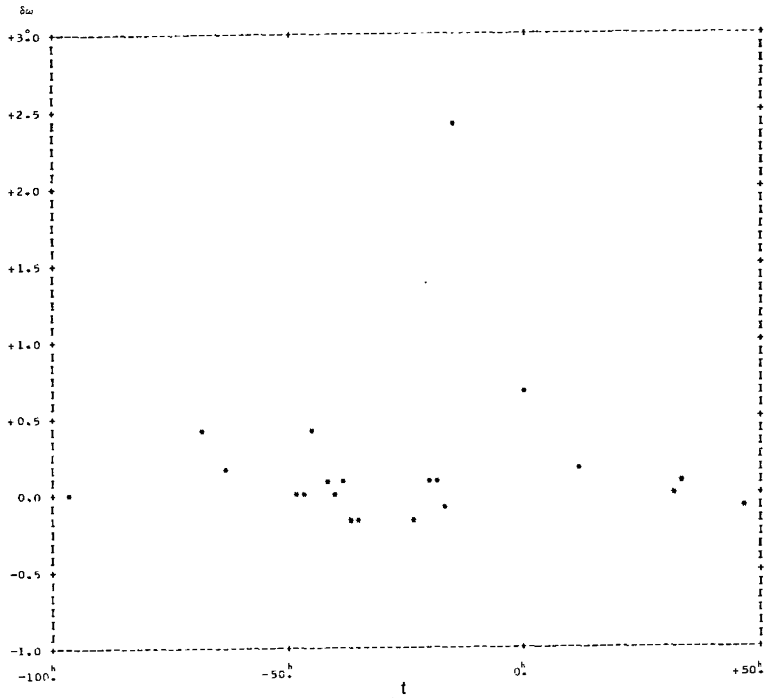

Figure 7e. Values of δω (degrees)

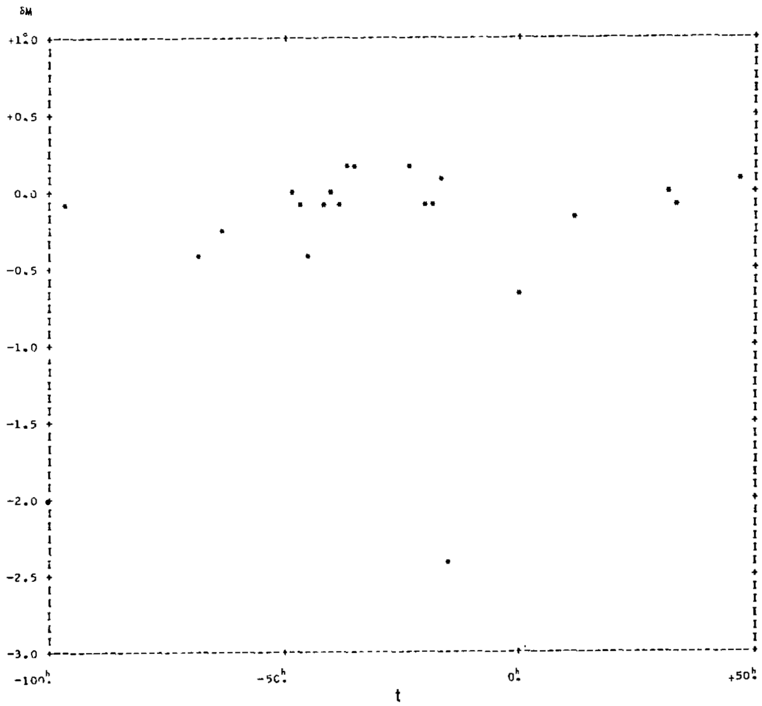

Figure 7f. Values of δM (degrees)

Figure 8 (a through f)— δa, δe, δI, $\delta\Omega$, $\delta\omega$, δM versus t (21 orbits corresponding to Table 6c).

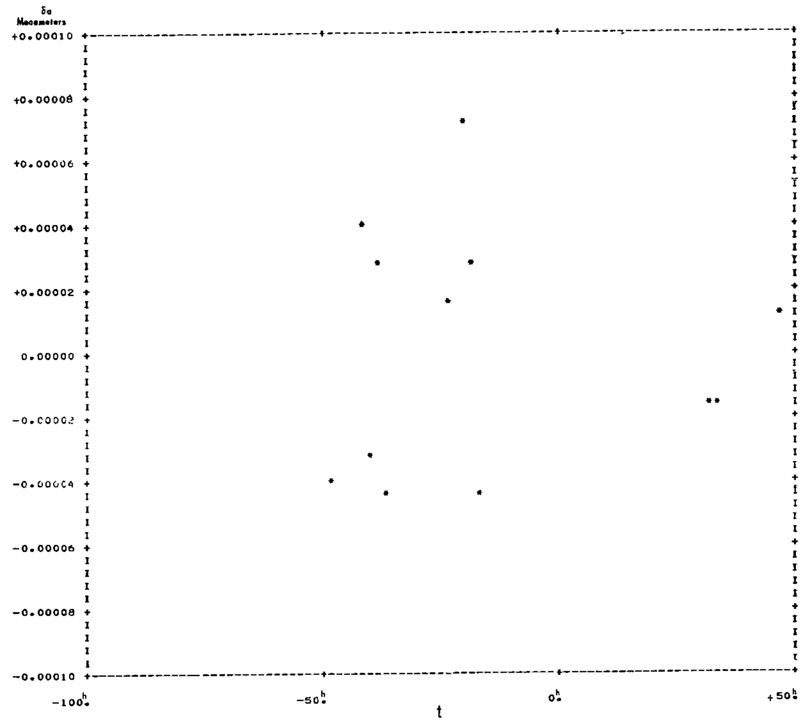

Figure 8a. Values of δa (megameters)

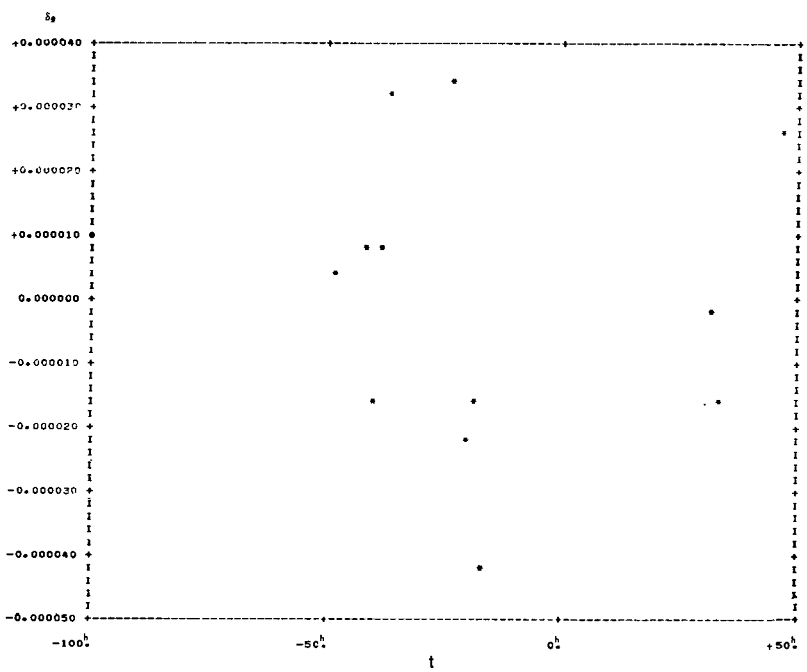

Figure 8b. Values of δe

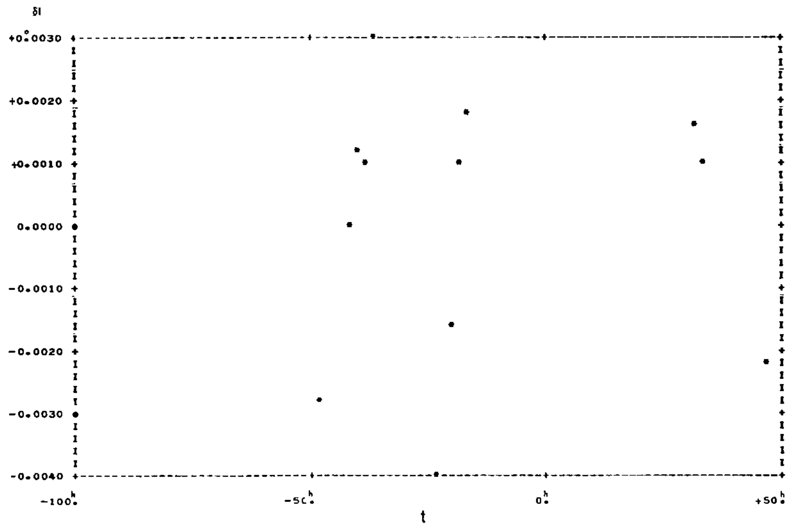

Figure 8c. Values of δI (degrees)

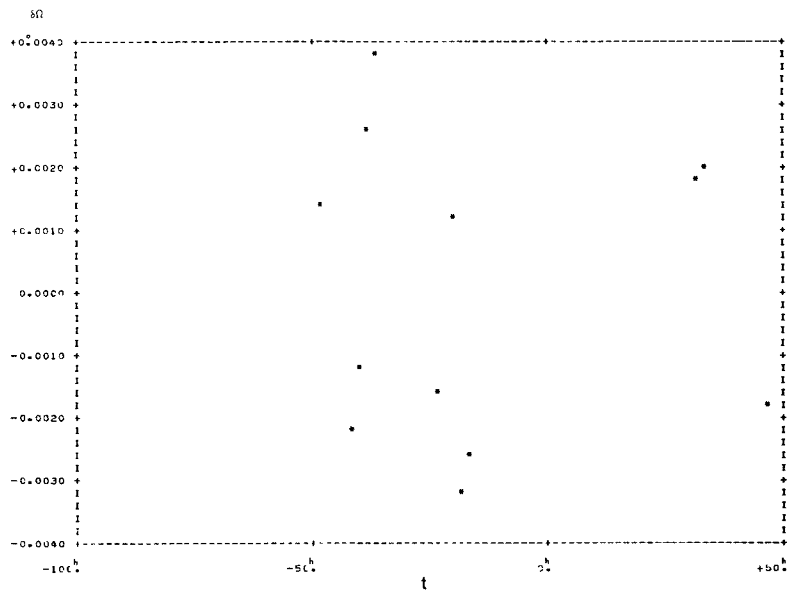

Figure 8d. Values of δΩ (degrees)

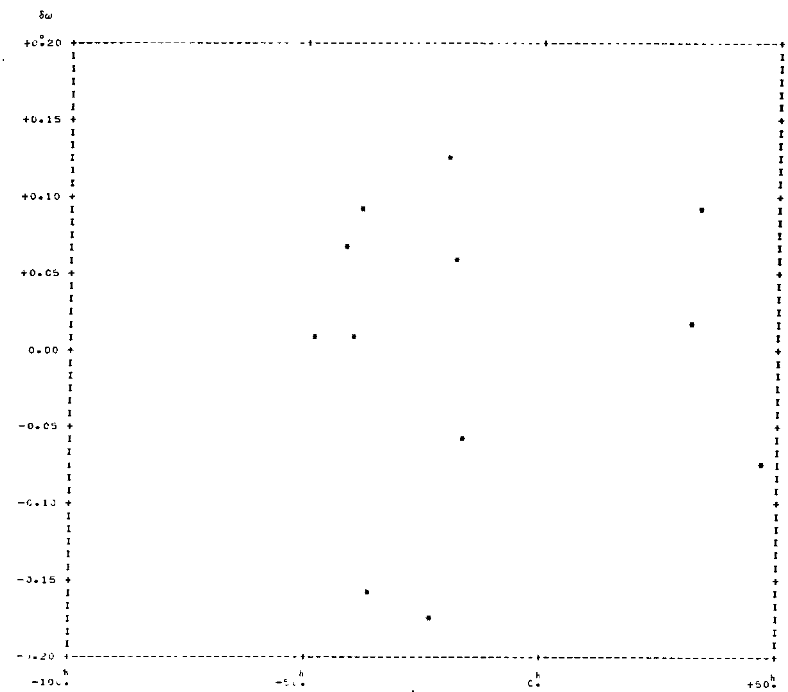

Figure 8e. Values of δω (degrees)

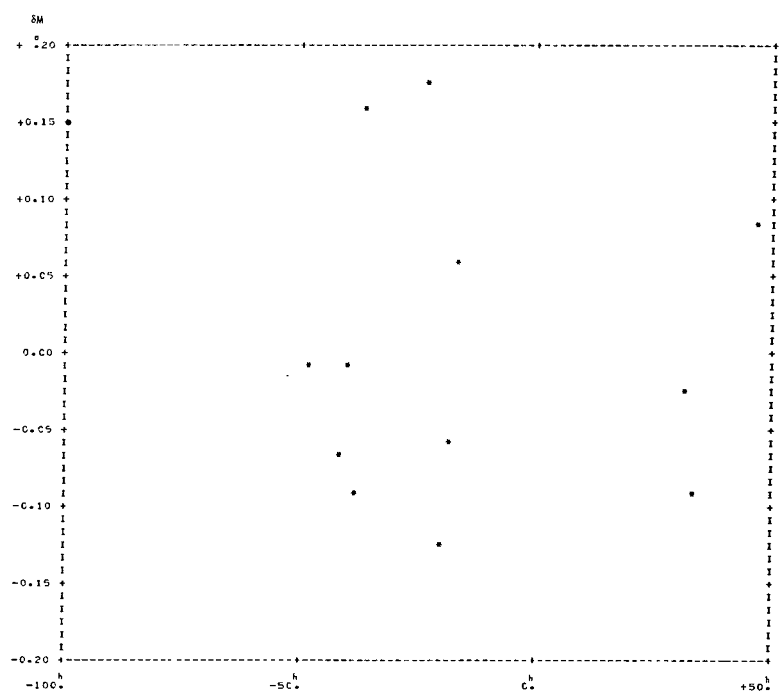

Figure 8f. Values of δM (degrees)

Figure 9 (a through u)—Residuals cos δ $\Delta\alpha$ in degrees versus mean anomaly in degrees for the 21 orbits of Table 6c.

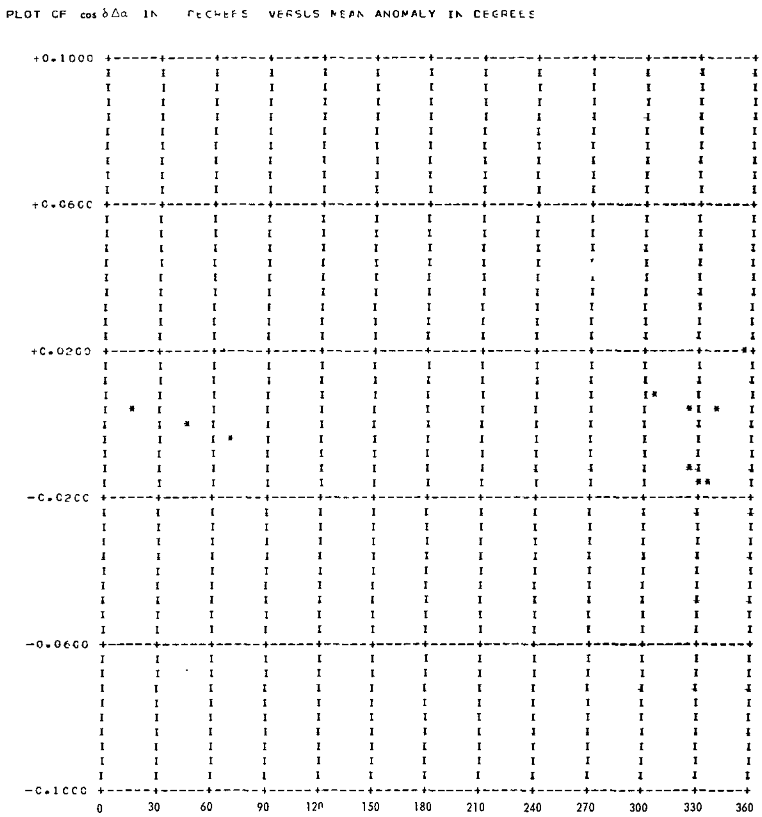

Figure 9a. Orbit 169 (t = $-96^h.81$)

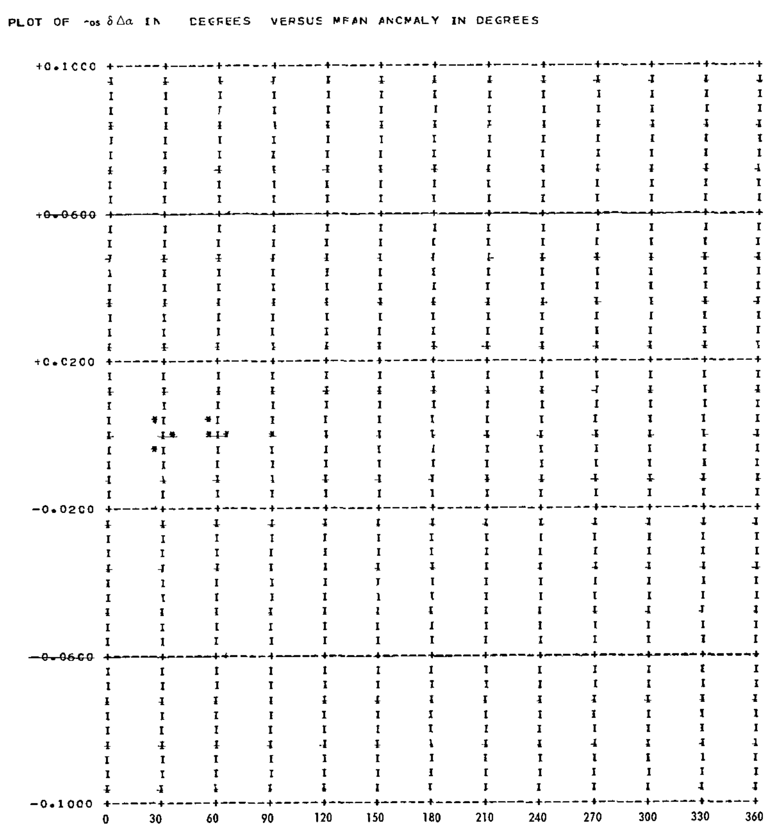

Figure 9b. Orbit 170 (t = $-68^h.22$)

PLOT OF $\cos \delta \Delta\alpha$ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

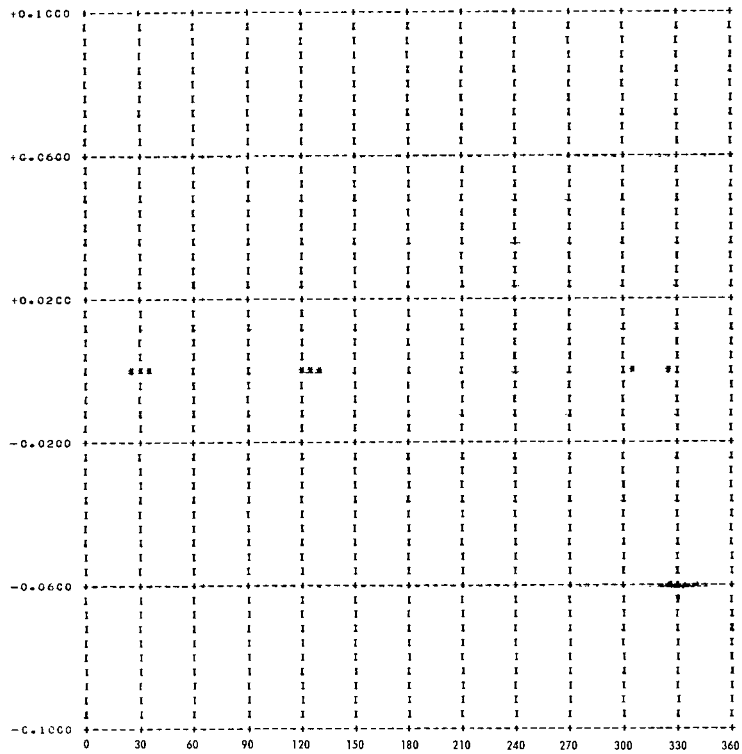

Figure 9c. Orbit 171 ($t = -62^h.54$)

PLOT OF $\cos \delta \Delta\alpha$ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

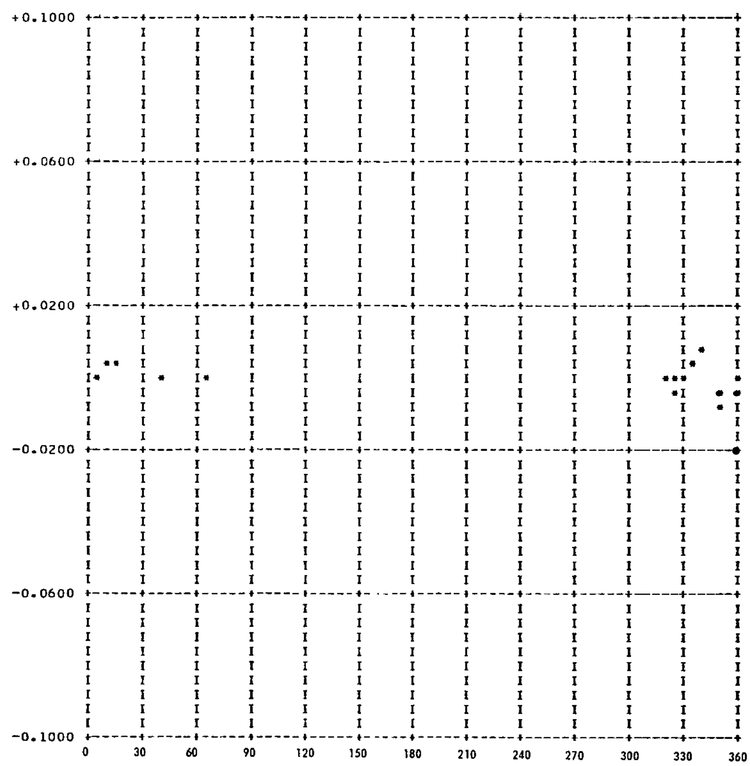

Figure 9d. Orbit 25 ($t = -48^h.48$)

PLOT OF $\cos \delta \Delta \alpha$ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

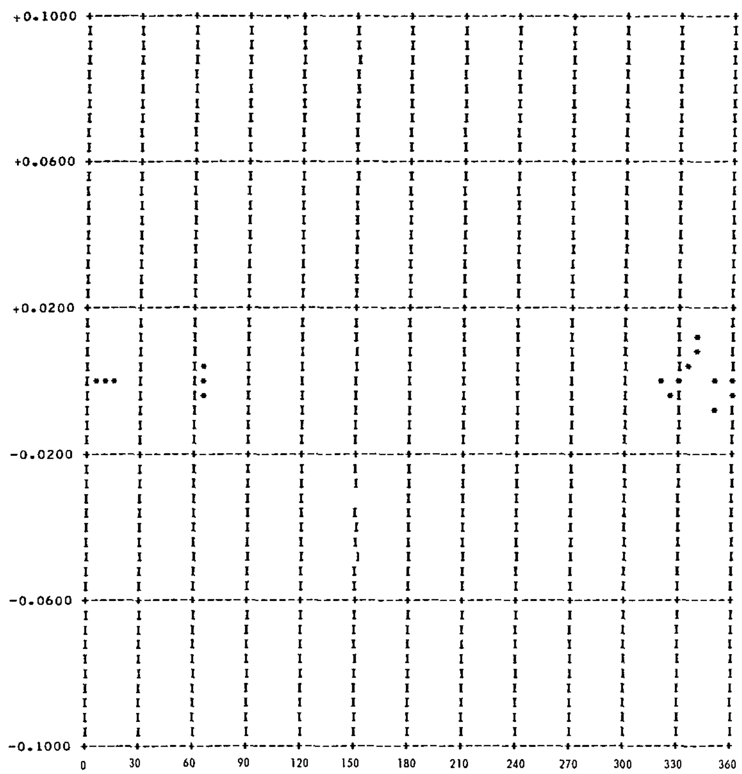

Figure 9e. Orbit 131 ($t = -46^h.79$)

PLOT OF $\cos \delta \Delta \alpha$ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

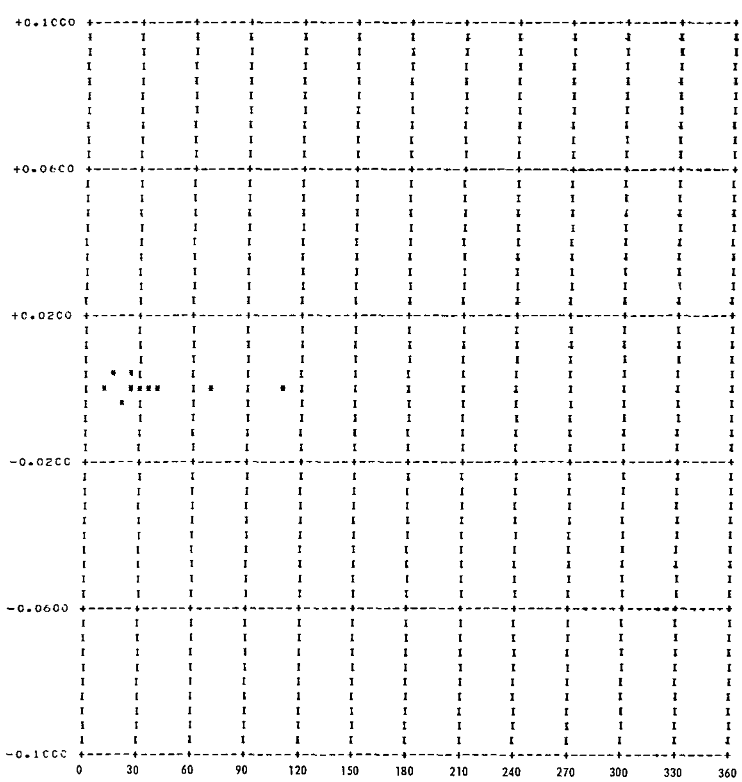

Figure 9f. Orbit 172 ($t = -44^h.49$)

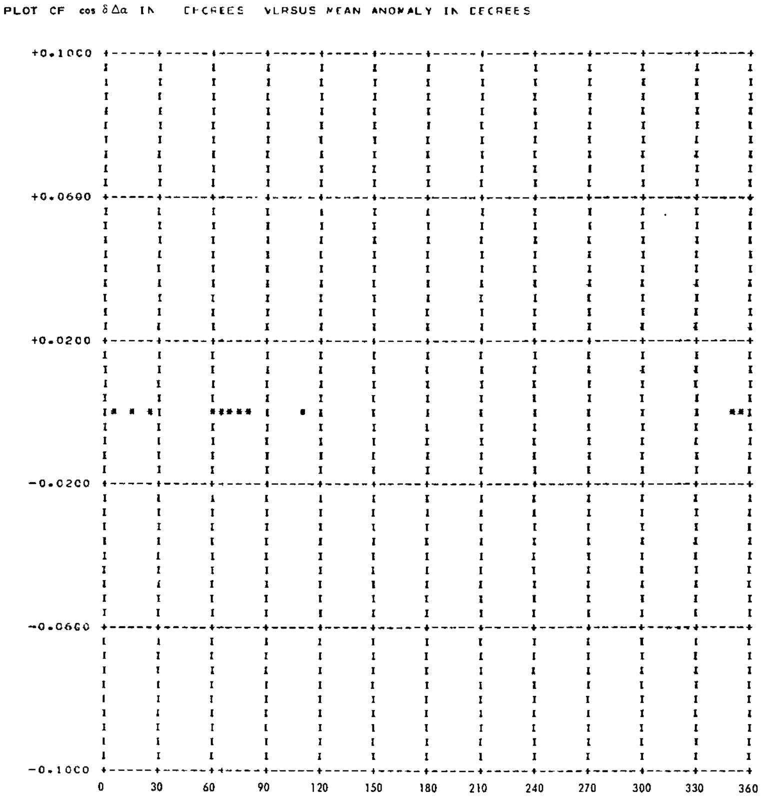

Figure 9g. Orbit 173 (t = $-42^h.44$)

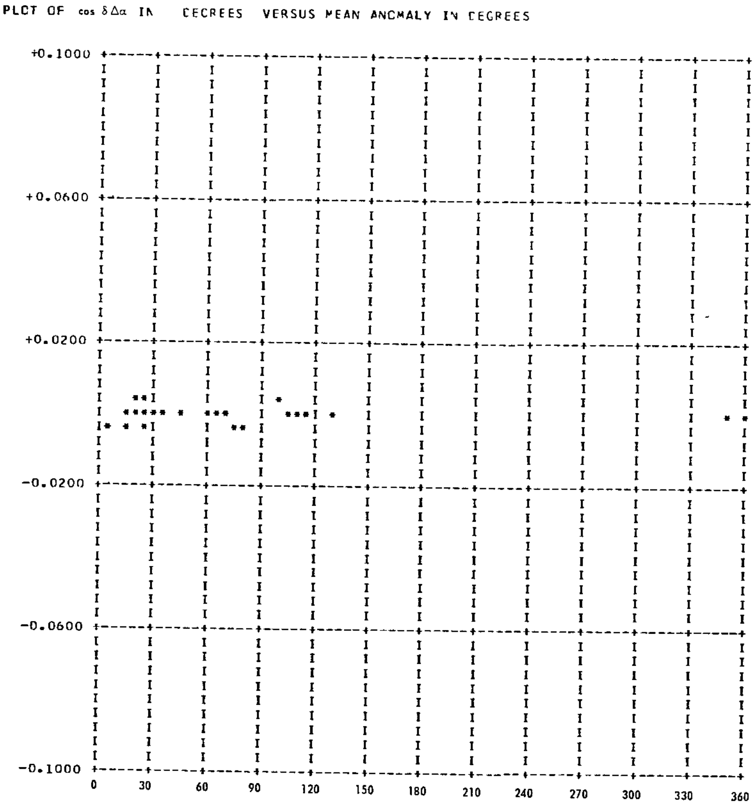

Figure 9h. Orbit 49 (t = $-40^h.53$)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

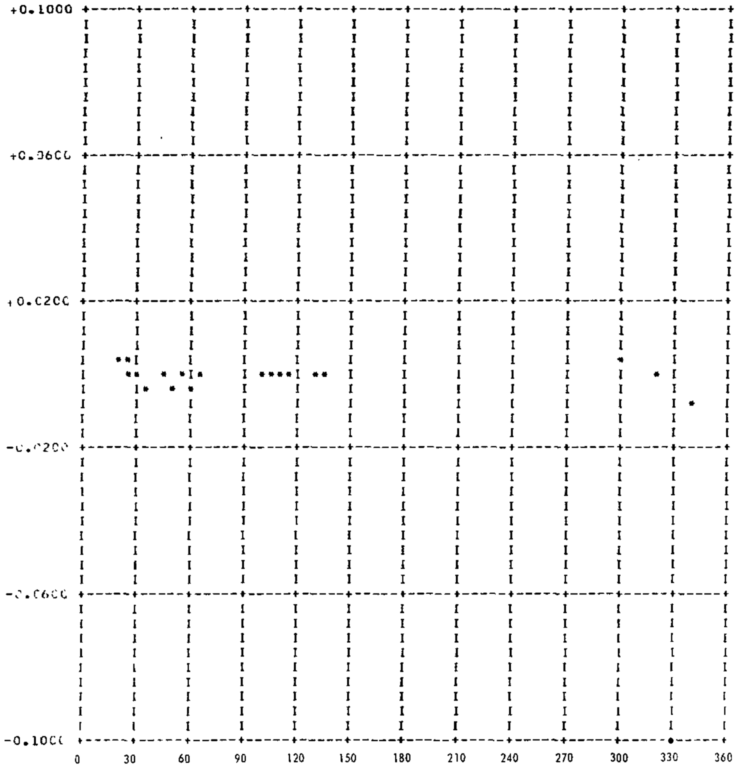

Figure 9i. Orbit 58 ($t = -38^h.67$)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

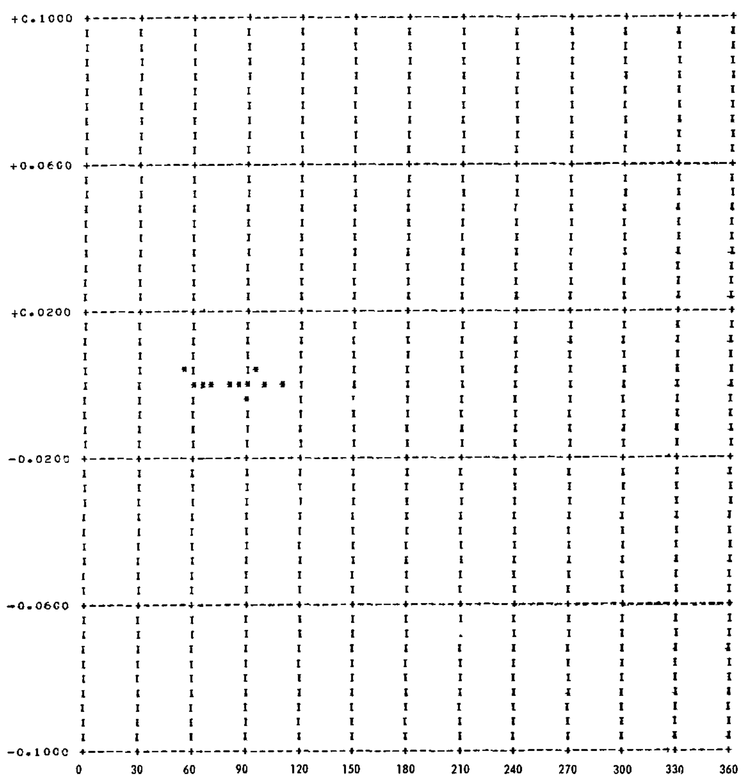

Figure 9j. Orbit 174 ($t = -36^h.48$)

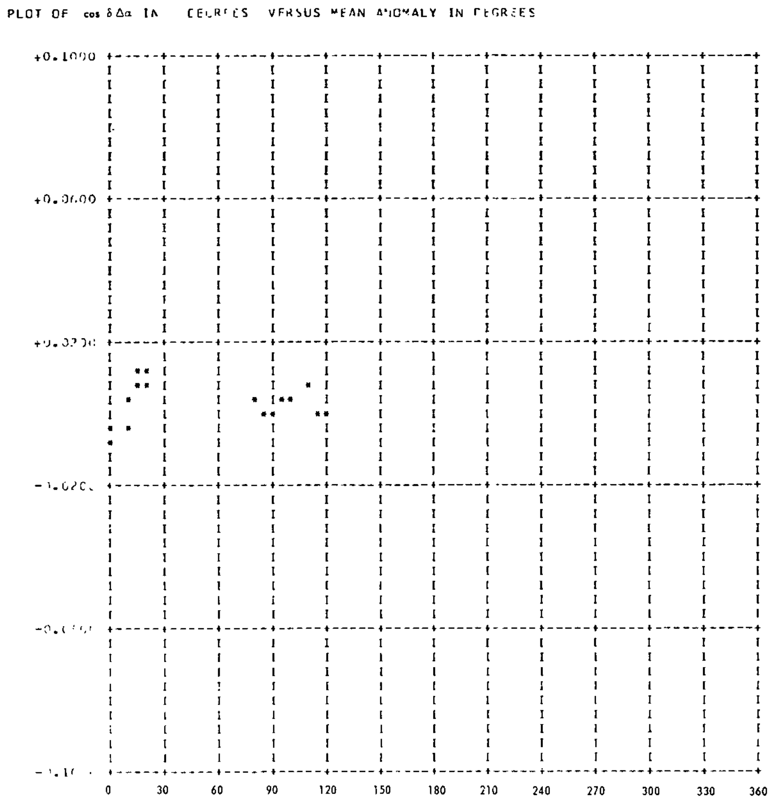

Figure 9k. Orbit 79 (t = $-34^h.36$)

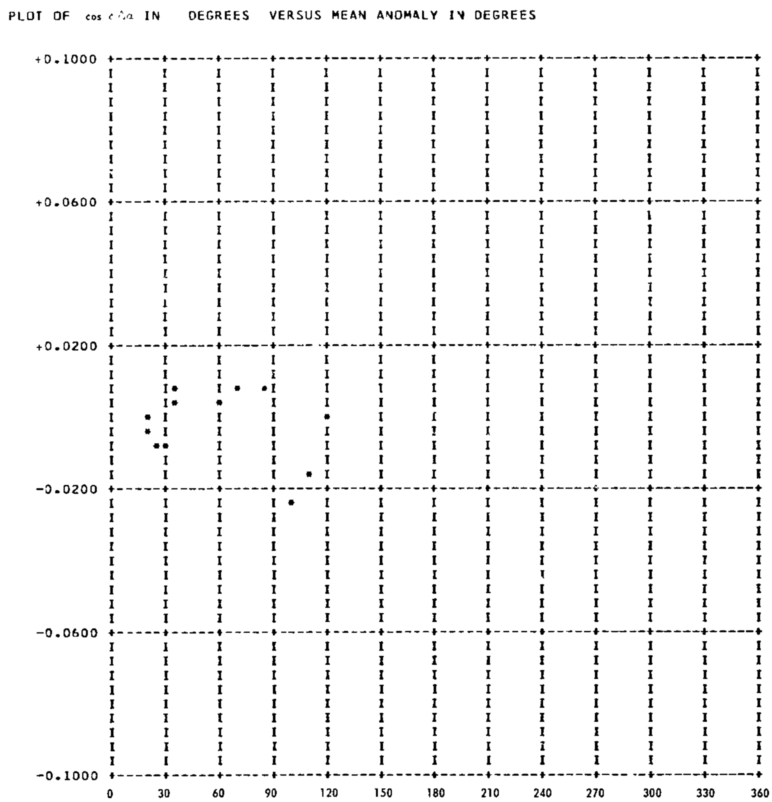

Figure 9*l*. Orbit 84 (t = $-23^h.79$)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

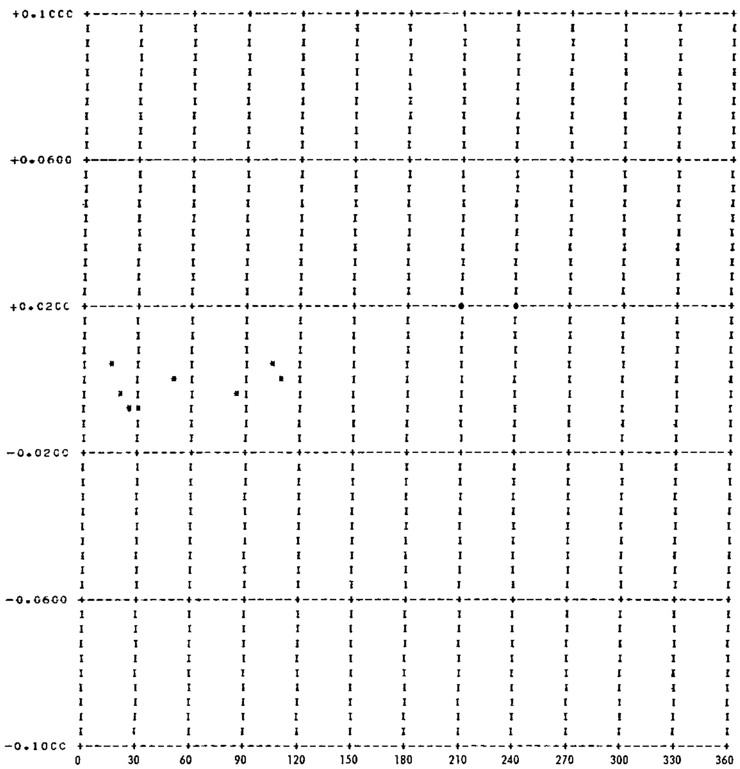

Figure 9m. Orbit 141 ($t = -20^h.81$)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

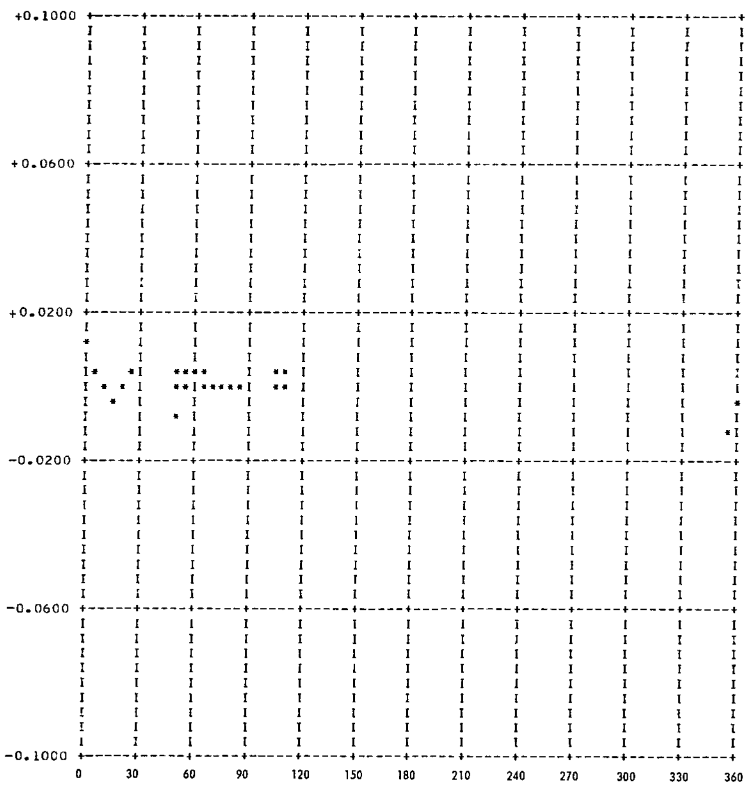

Figure 9n. Orbit 100 ($t = -18^h.83$)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

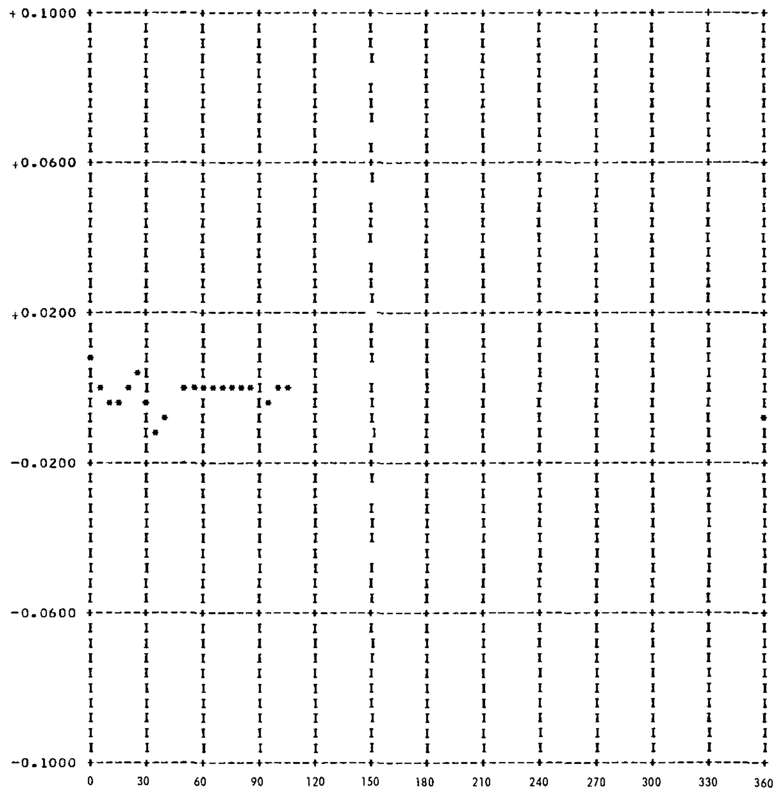

Figure 9o. Orbit 116 (t = $-16^h.94$)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

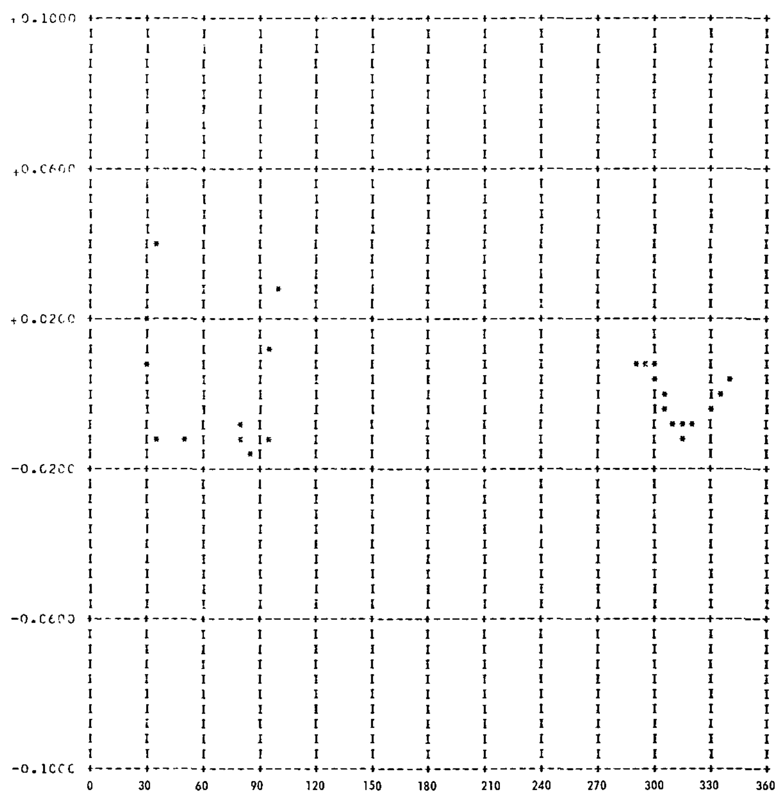

Figure 9p. Orbit 143 (t = $-15^h.22$)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

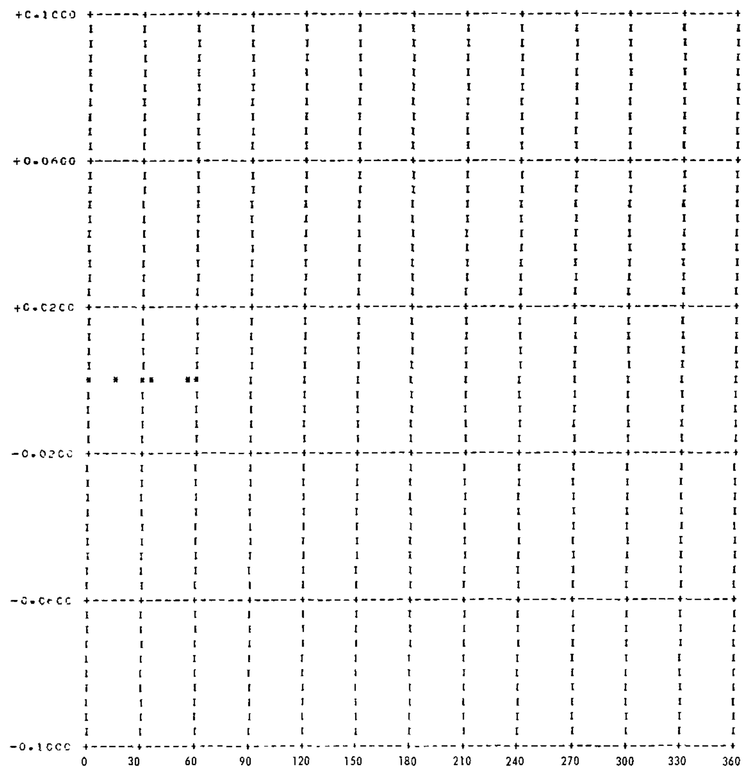

Figure 9q. Orbit 180 (t = − 0^h.28)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

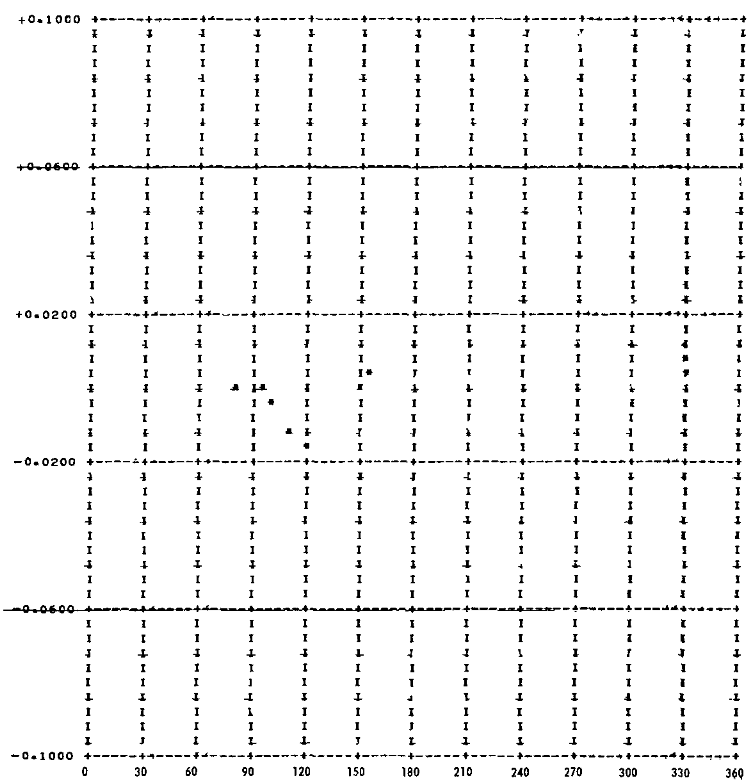

Figure 9r. Orbit 181 (t = +11^h.62)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

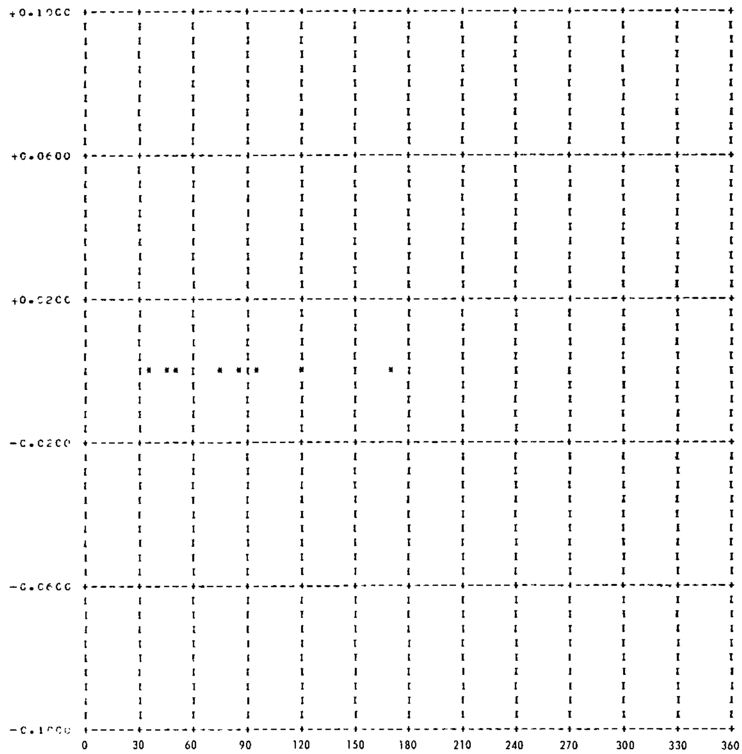

Figure 9s. Orbit 177 (t = +31^h.72)

PLOT OF cos δΔα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

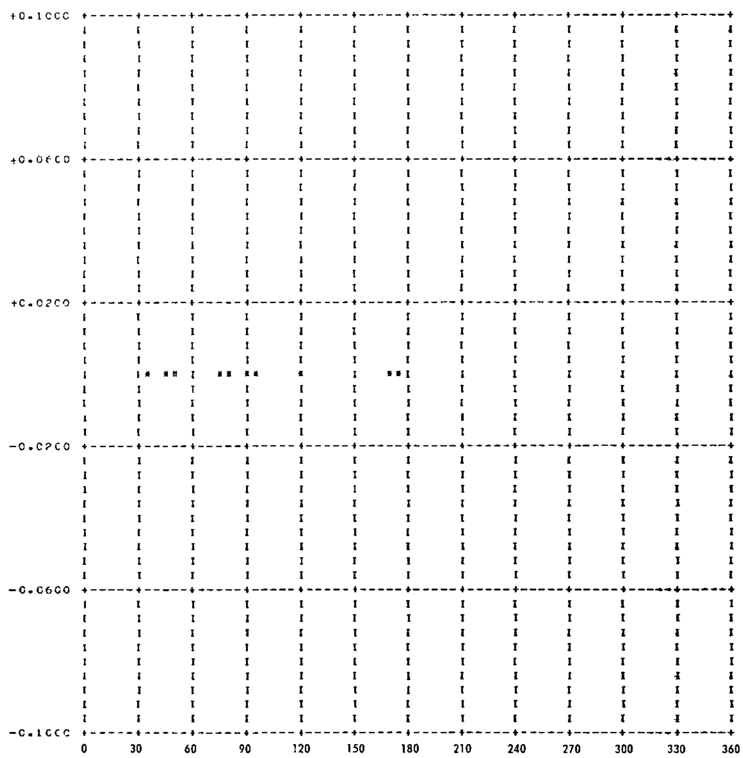

Figure 9t. Orbit 178 (t = +33^h.40)

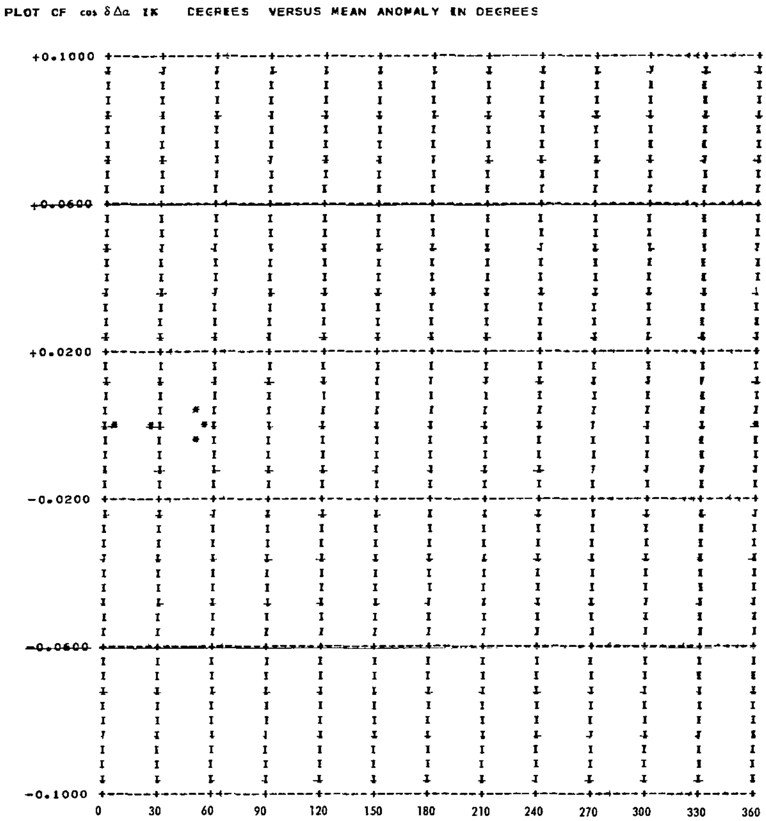

Figure 9u. Orbit 179 (t = +46^h.98)

Figure 10 (a through u)—Residual $\Delta\delta$ in degrees versus mean anomaly in degrees for the 21 orbits of Table 6c.

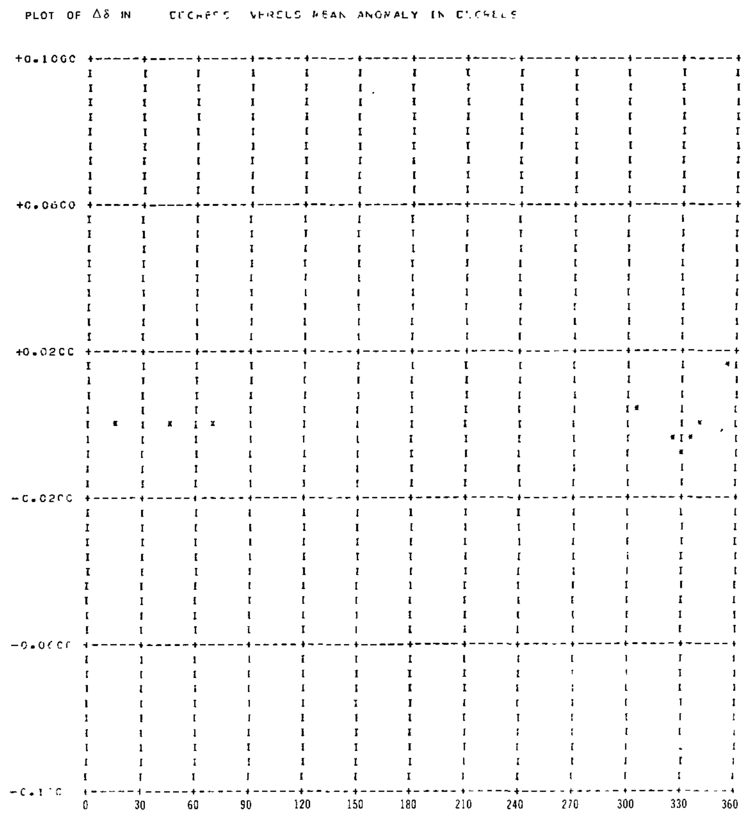

Figure 10a. Orbit 169 ($t = -96^h.81$)

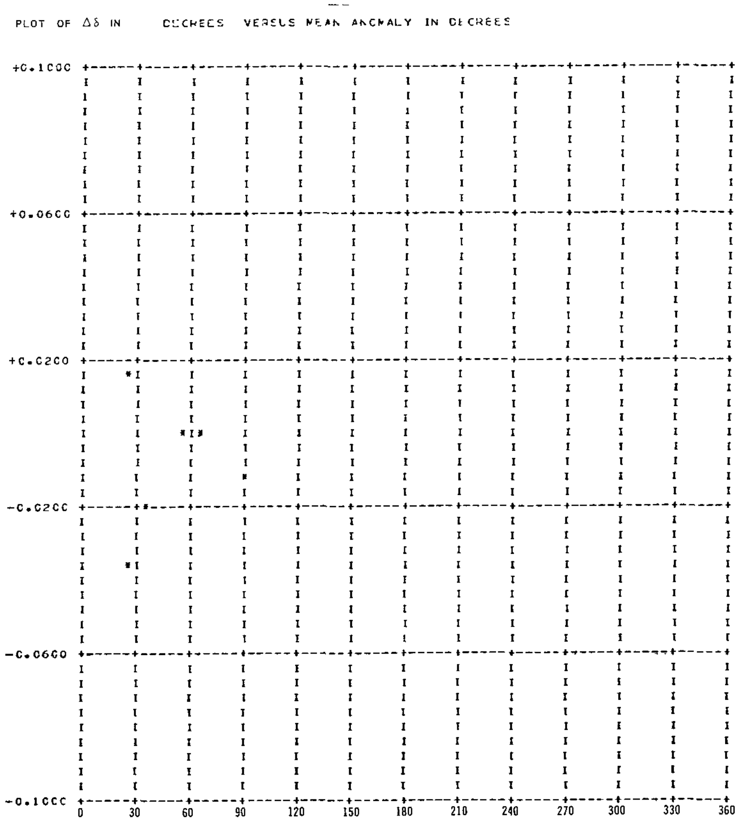

Figure 10b. Orbit 170 ($t = -68^h.22$)

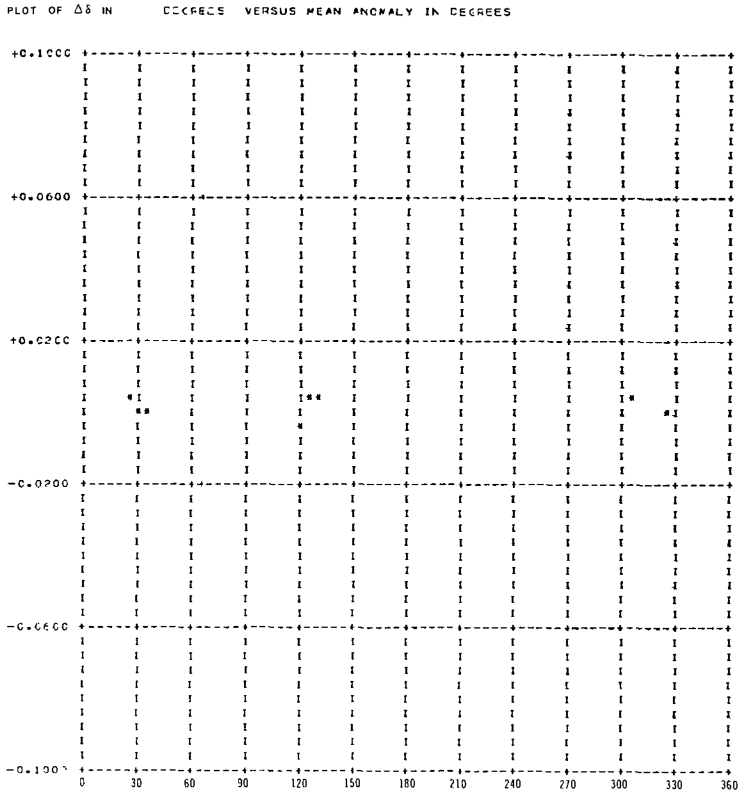

Figure 10c. Orbit 171 ($t = -62^h.54$)

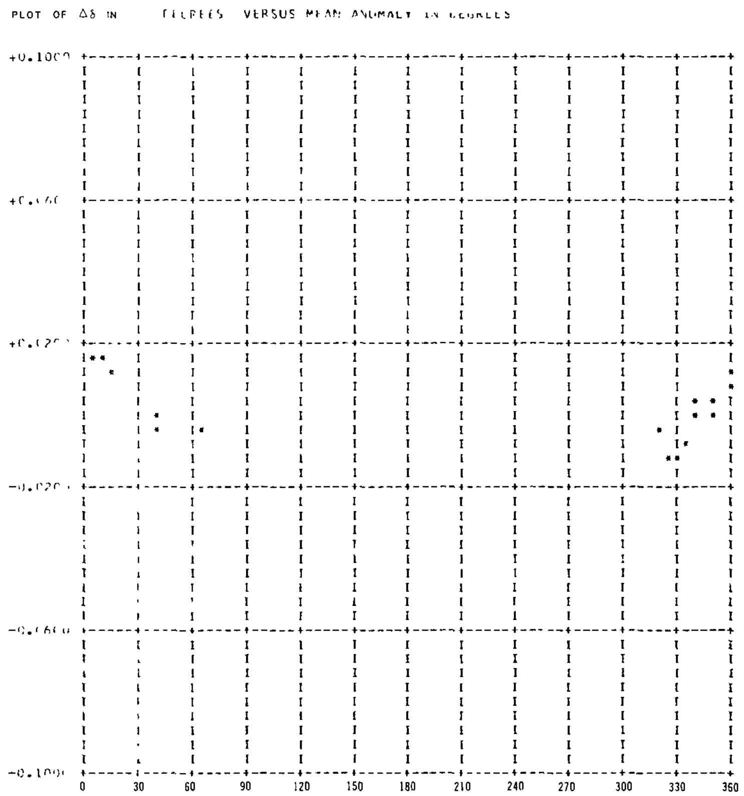

Figure 10d. Orbit 25 ($t = -48^h.48$)

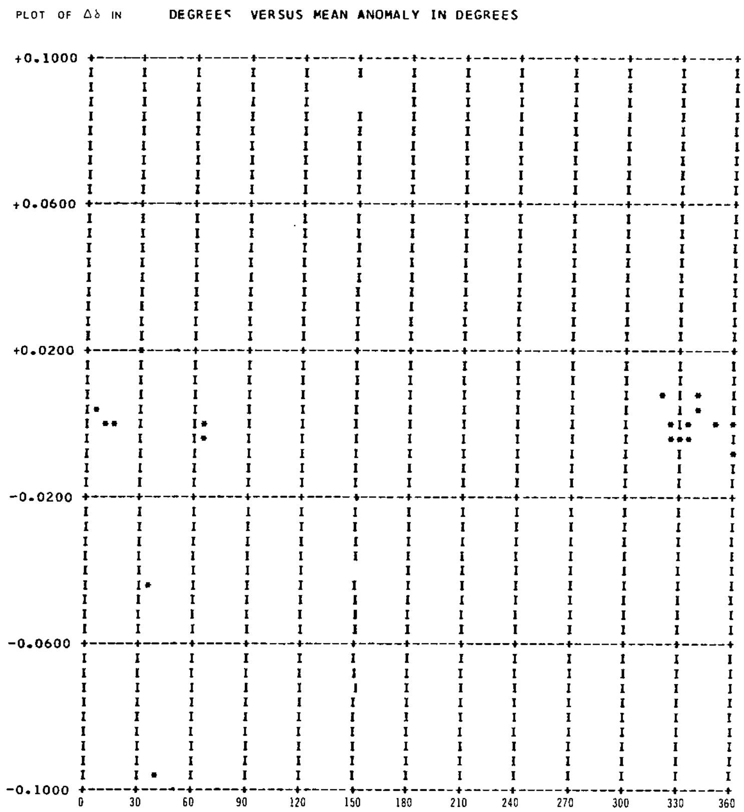

Figure 10e. Orbit 131 (t = $-46^h.79$)

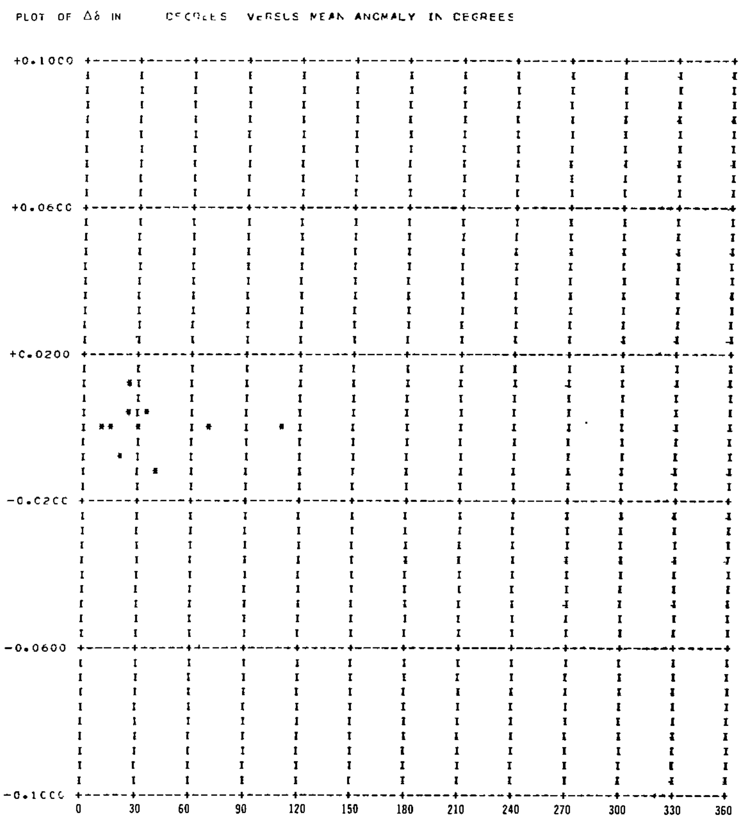

Figure 10f. Orbit 172 (t = $-44^h.49$)

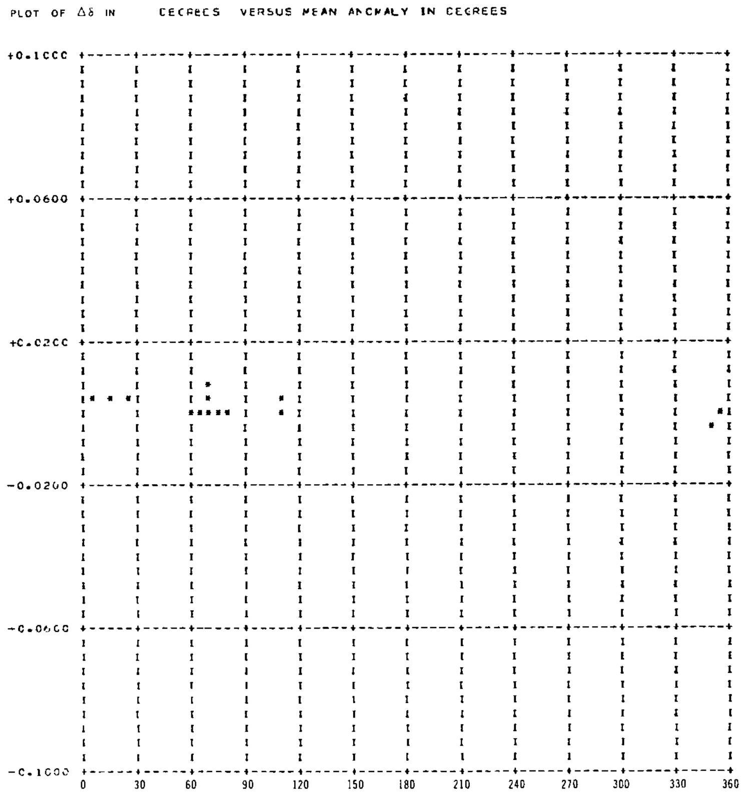

Figure 10g. Orbit 173 (t = $-42^h.44$)

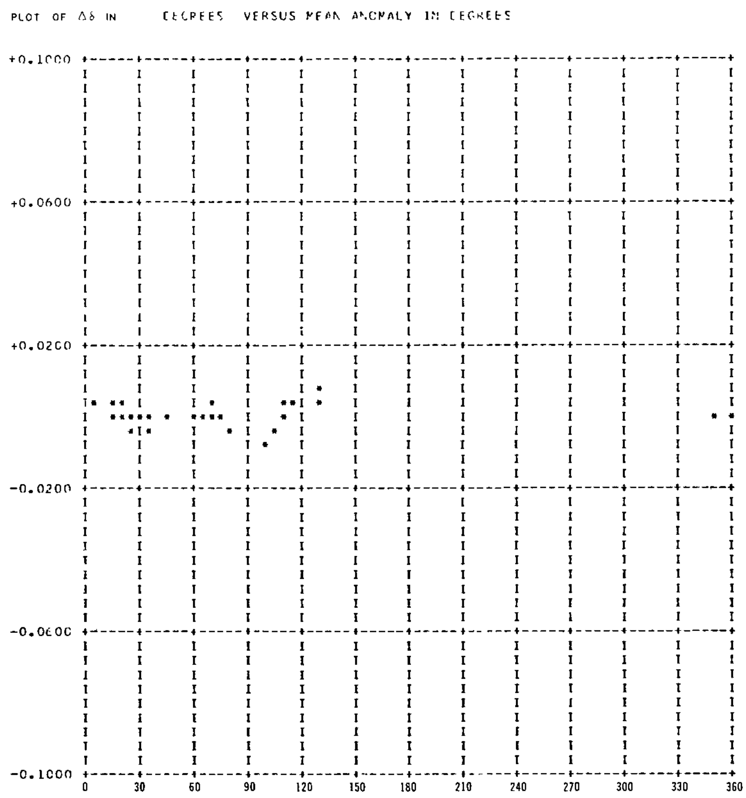

Figure 10h. Orbit 49 (t = $-40^h.53$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

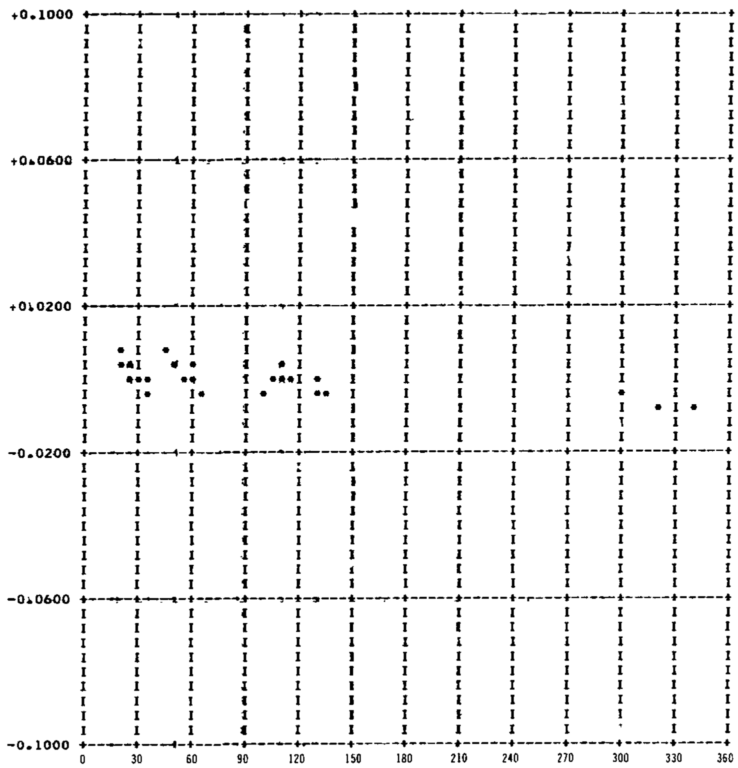

Figure 10i. Orbit 58 (t = $-38^h.67$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

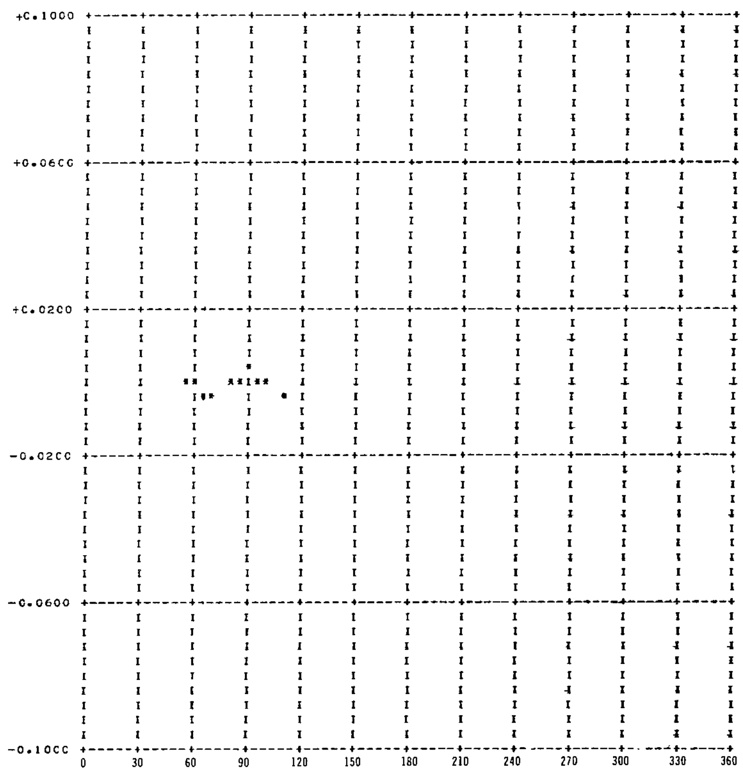

Figure 10j. Orbit 174 (t = $-36^h.48$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

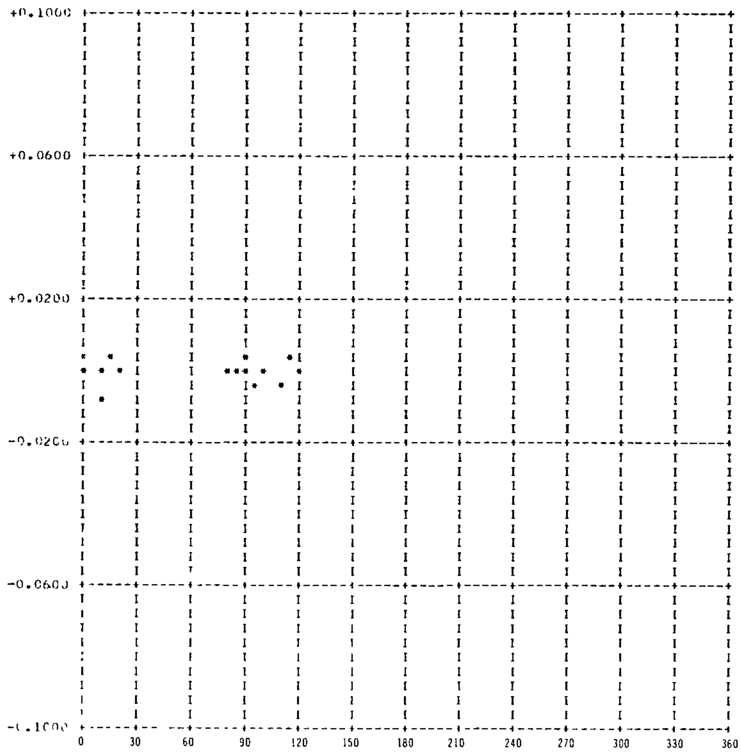

Figure 10k. Orbit 79 (t = $-34^h.36$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

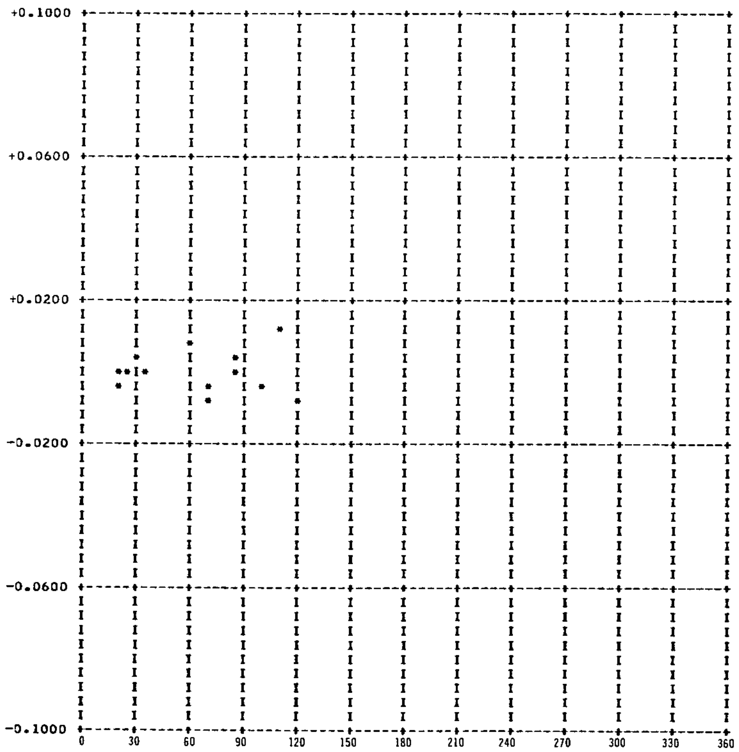

Figure 10*l*. Orbit 84 (t = $-23^h.79$)

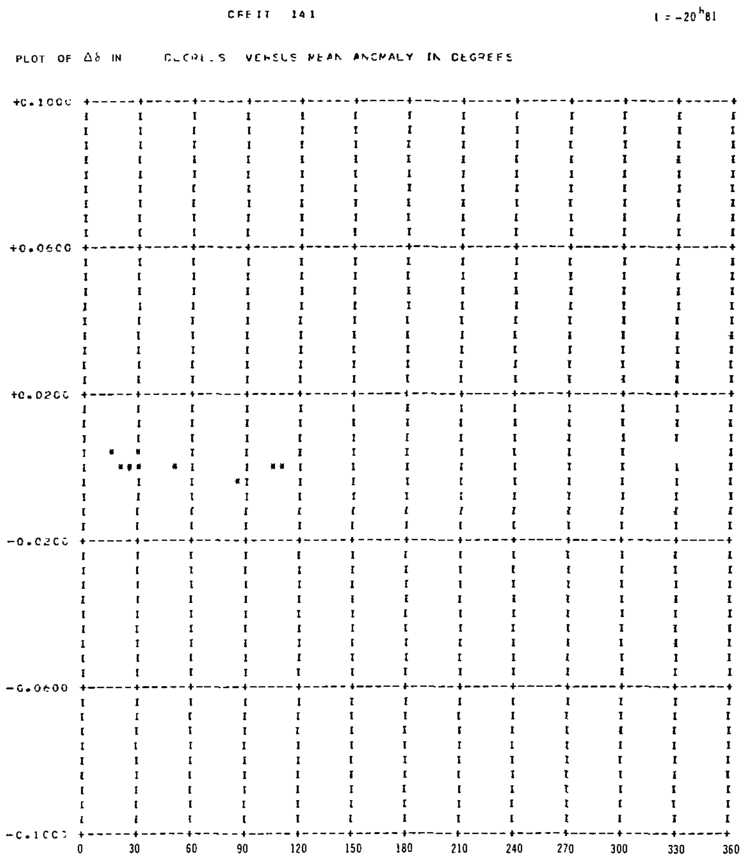

Figure 10m. Orbit 141 ($t = -20^h.81$)

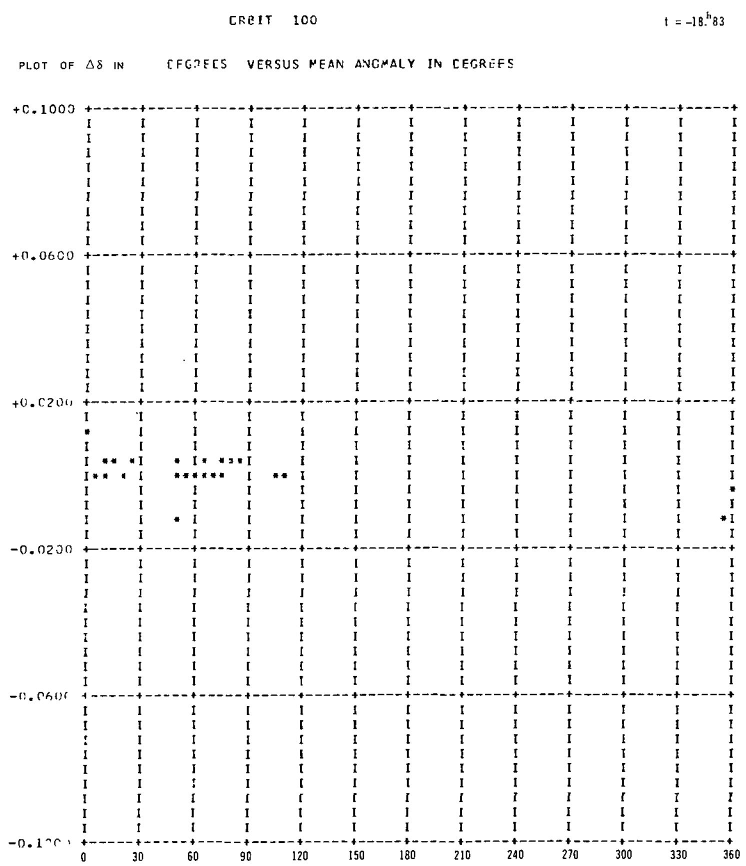

Figure 10n. Orbit 100 ($t = -18^h.83$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

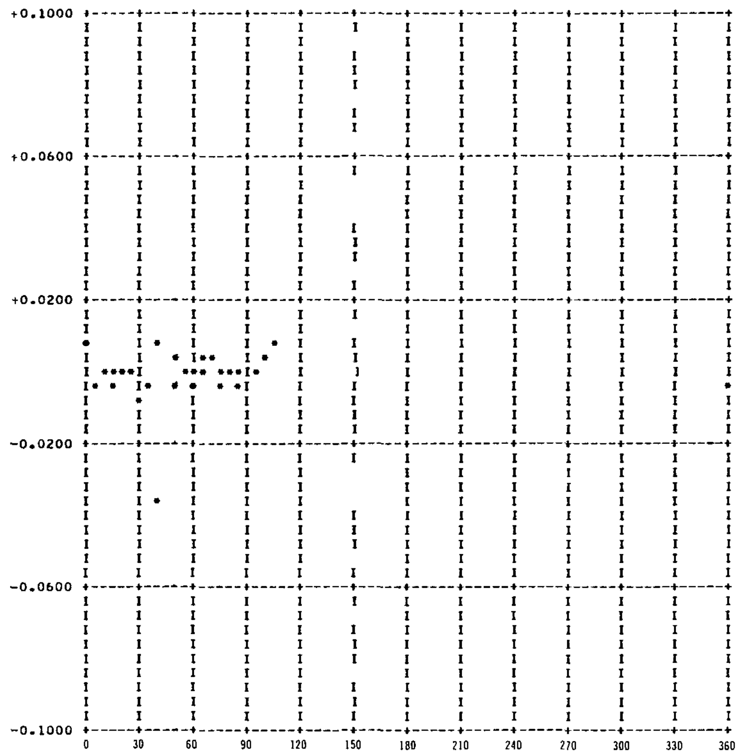

Figure 10o. Orbit 116 (t = $-16^h.94$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

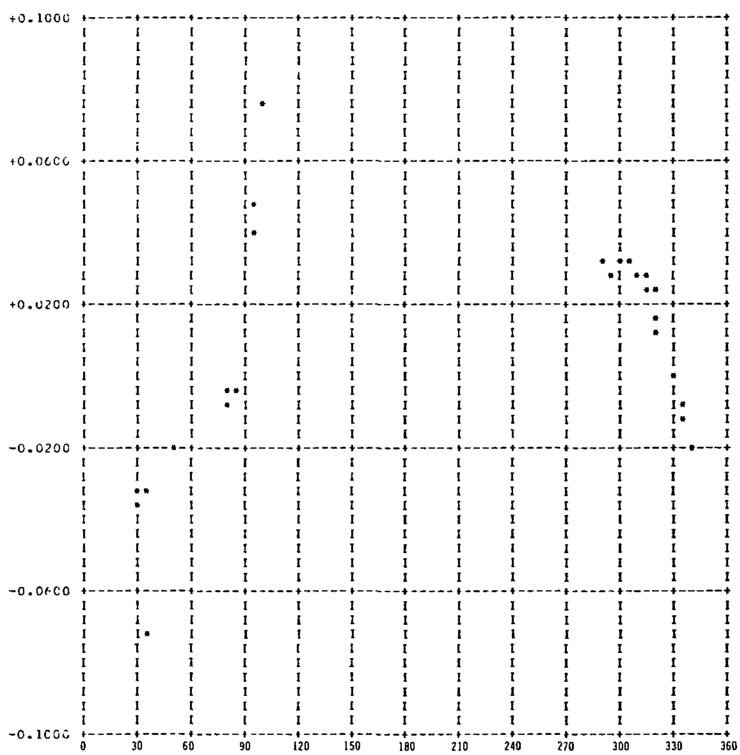

Figure 10p. Orbit 143 (t = $-15^h.22$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

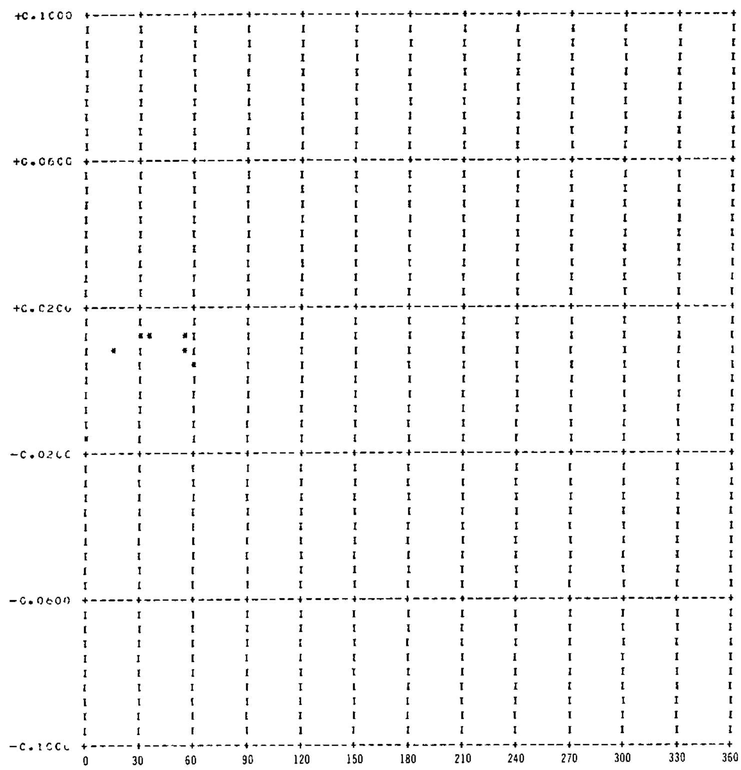

Figure 10q. Orbit 180 (t = $-0^h.28$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

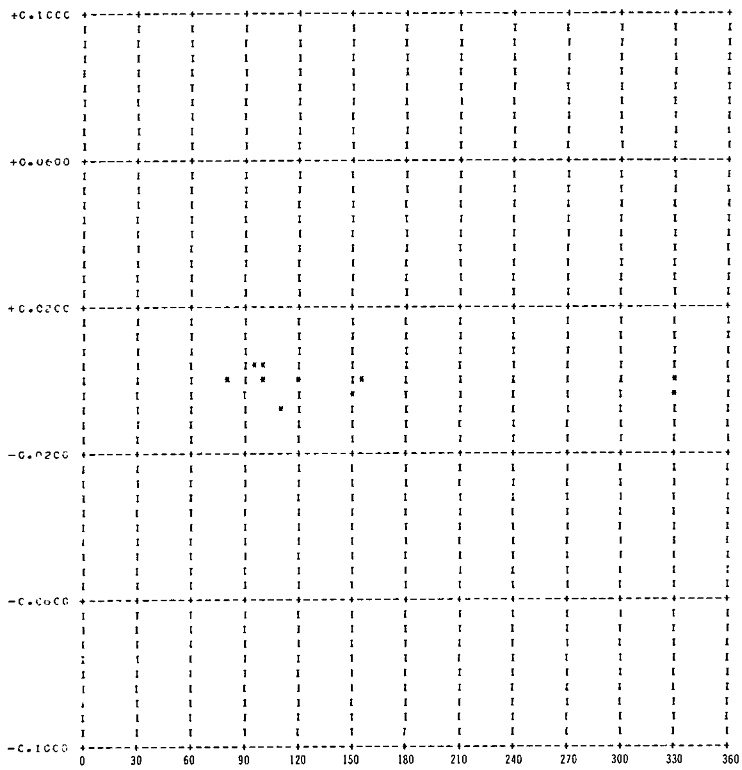

Figure 10r. Orbit 181 (t = $+11^h.62$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

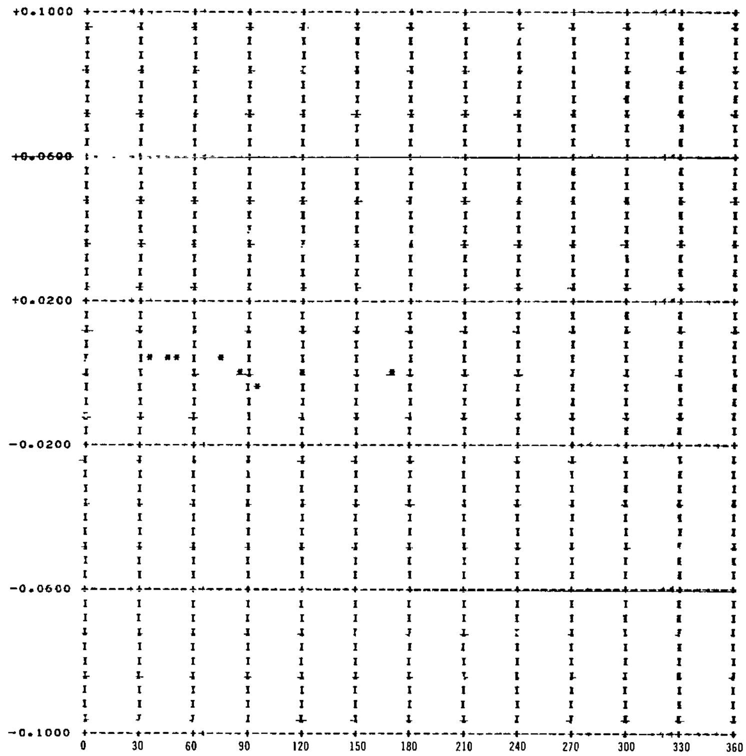

Figure 10s. Orbit 177 (t = +31^{h}.72)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

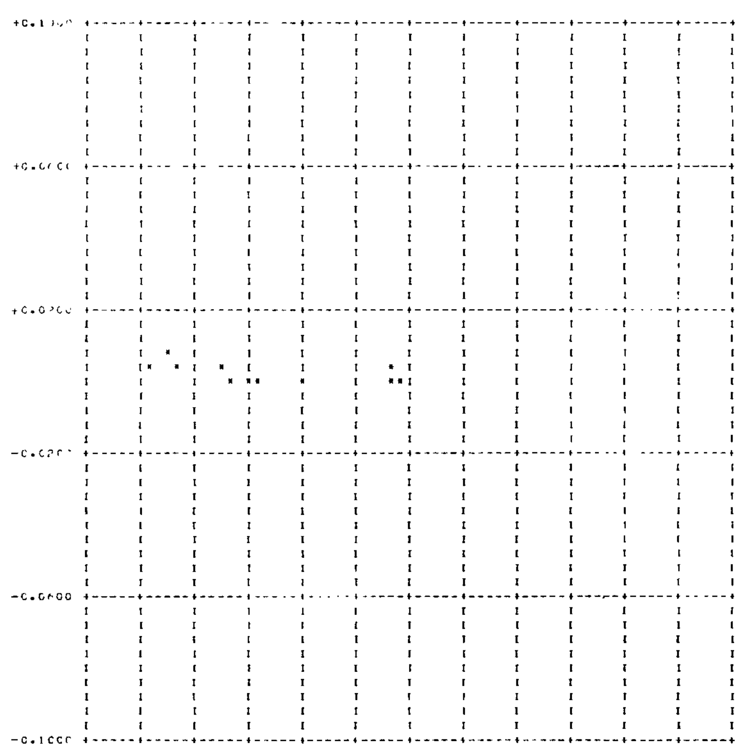

Figure 10t. Orbit 178 (t = +33^{h}.40)

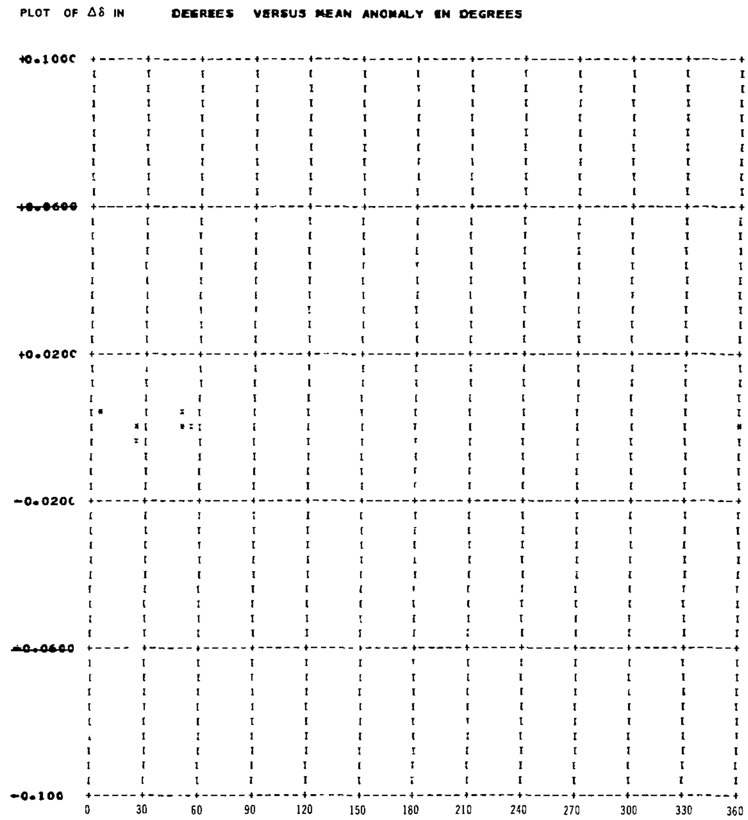

Figure 10u. Orbit 179 (t = +46^h.98)

Figure 11 (a through e)—Residuals cos δ $\Delta\alpha$ in degrees versus mean anomaly in degrees (orbits 182 to 186).

PLOT OF cos δΔι IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

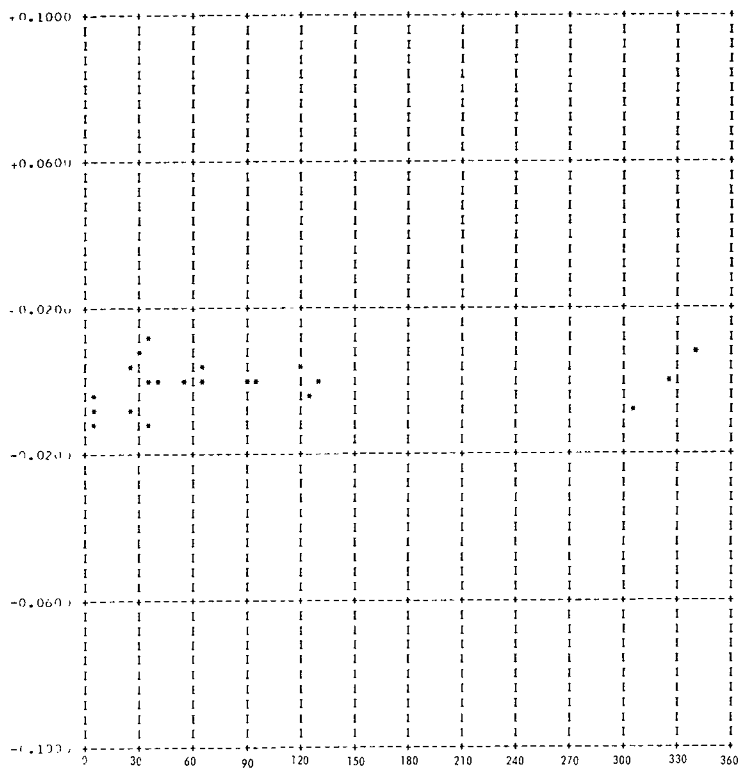

Figure 11a. Orbit 182 (t = -60ʰ.00)

PLOT OF cos δ'α IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

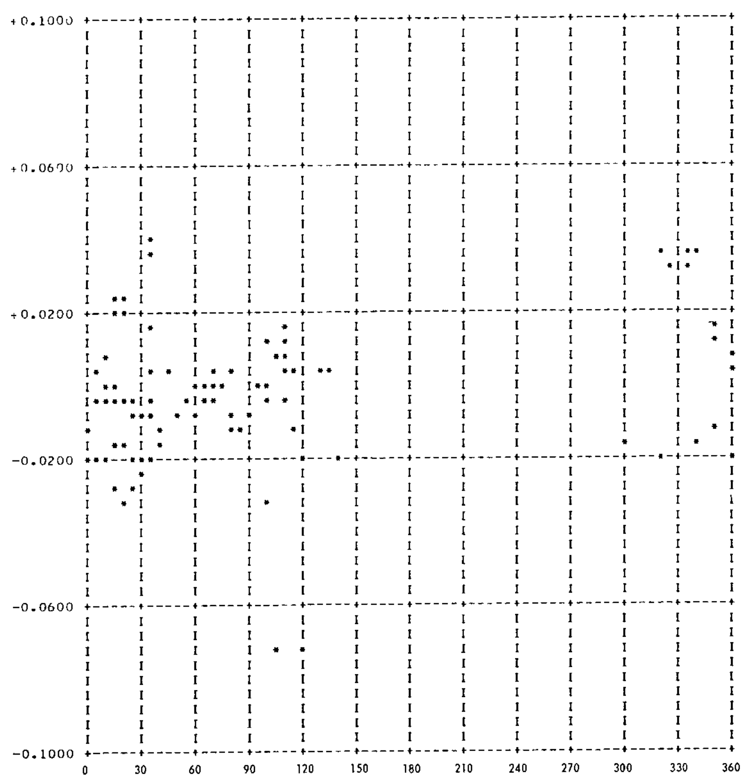

Figure 11b. Orbit 183 (t = -36ʰ.00)

PLOT OF cos δ Δα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

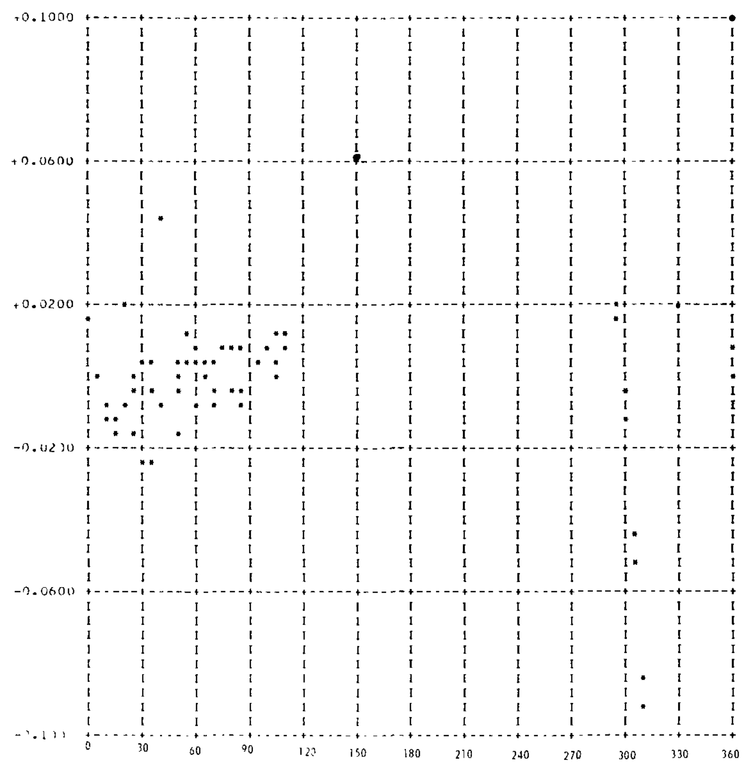

Figure 11c. Orbit 184 (t = -12ʰ.00)

PLOT OF cos δ Δα IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

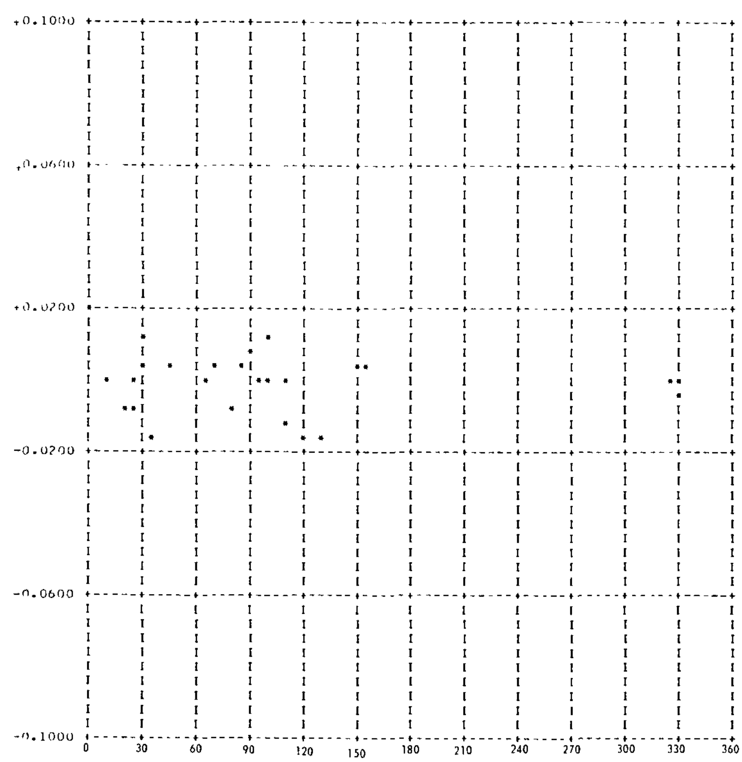

Figure 11d. Orbit 185 (t = +12ʰ.00)

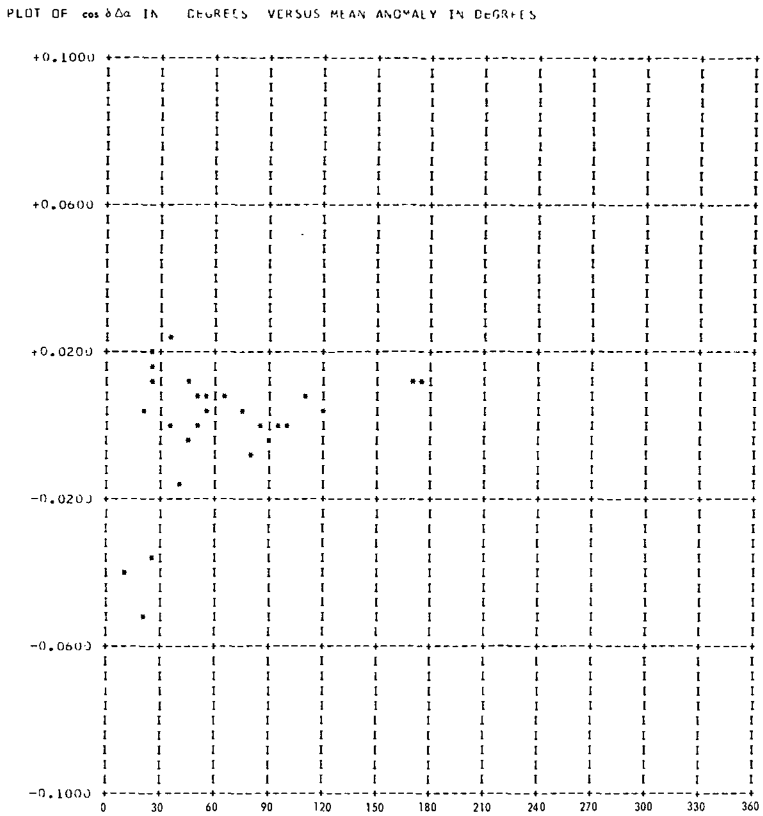

Figure 11e. Orbit 186 (t = +36^h.00)

Figure 12 (a through e)—Residual $\Delta\delta$ in degrees versus mean anomaly in degrees (orbits 182 to 186).

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

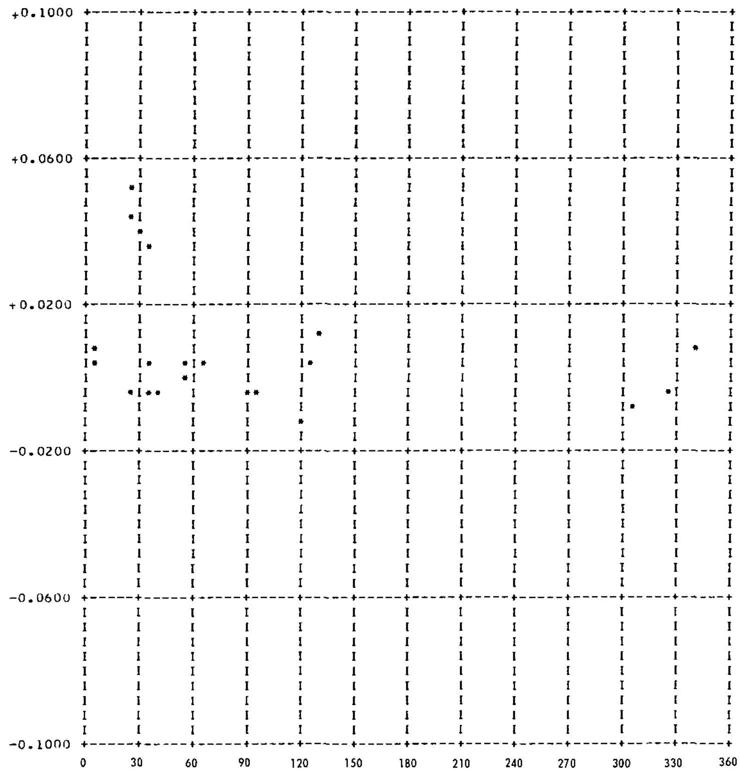

Figure 12a. Orbit 182 ($t = -60^h.00$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

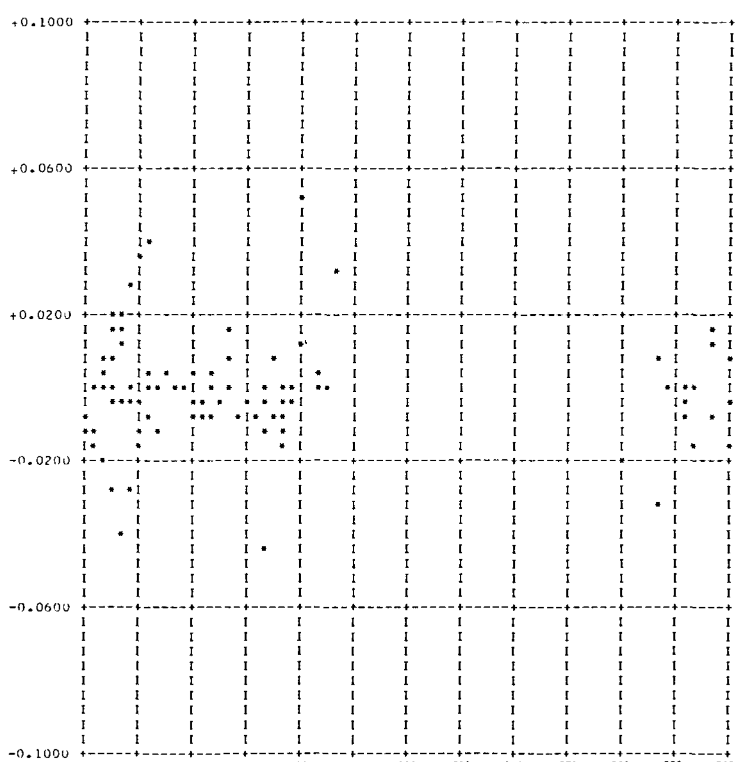

Figure 12b. Orbit 183 ($t = -36^h.00$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

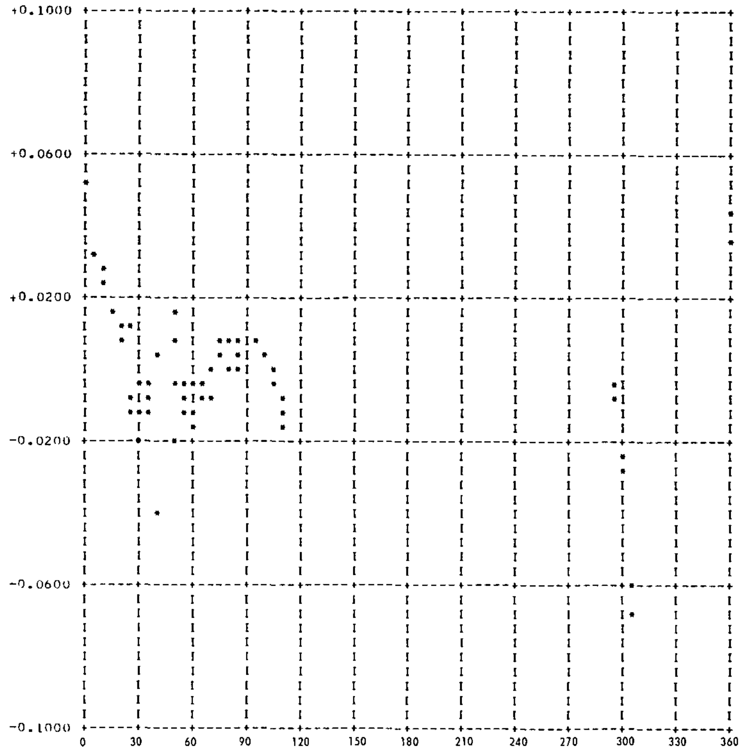

Figure 12c. Orbit 184 ($t = -12^{h}.00$)

PLOT OF Δδ IN DEGREES VERSUS MEAN ANOMALY IN DEGREES

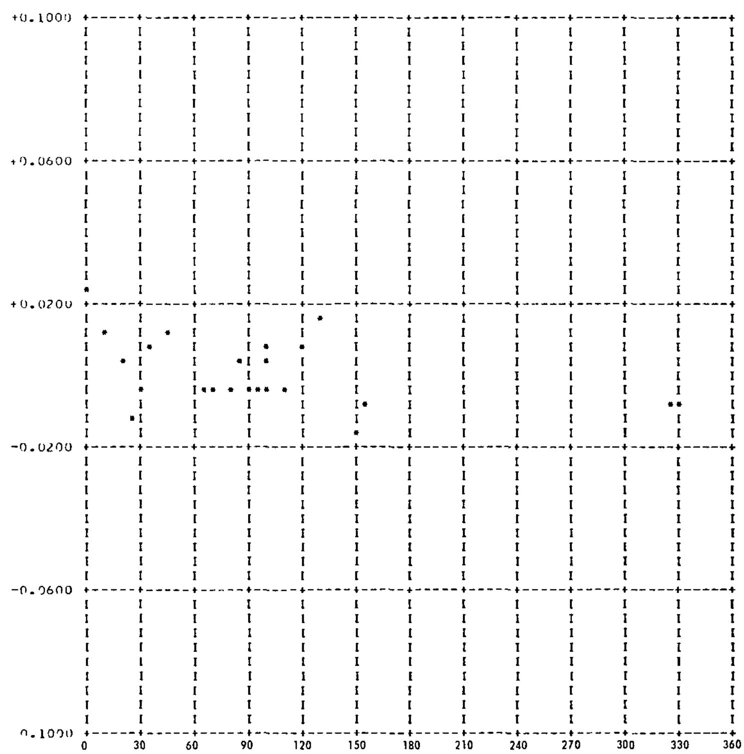

Figure 12d. Orbit 185 ($t = +12^{h}.00$)

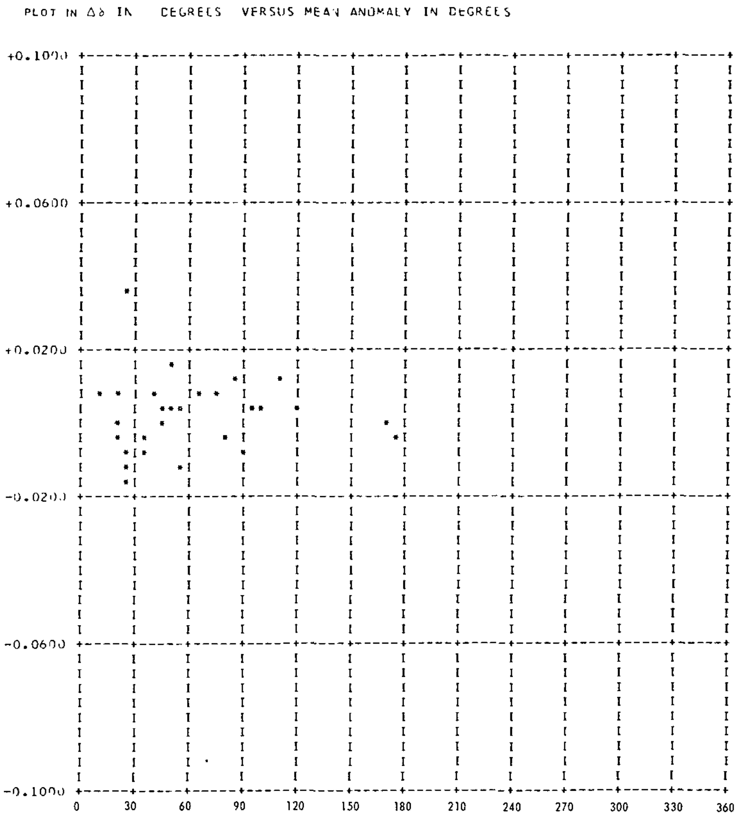

Figure 12e. Orbit 186 (t = +36ʰ.00)

NASA-Langley, 1966 G-605

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—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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