

FUTURE ORBITS FOR TEN COMETS OF THE GENERAL CATALOGUE OF ORIGINAL AND FUTURE COMET ORBITS

Z. Sekanina, Centre for Numerical Mathematics, Faculty of Mathematics and Physics,
Charles University, Praha

Received May 3, 1966

The present paper is a continuation of a previous paper in 1966. Future orbits for ten comets are computed here, for which only original orbits have been known so far. In addition to the future orbits the values of the total energy changes of orbits of the ten comets are derived during their passing through the planetary system.

Будущие орбиты десяти комет включенных в Общій каталог первоначальных и будущих орбит комет. Настоящая работа является продолжением моей работы из 1966 г. Приводятся будущие орбиты 10 комет включенных в моем Общем каталоге первоначальных и будущих орбит комет, для которых до сих пор была известна только первоначальная орбита. Вместе с будущими орбитами определены также значения суммарного изменения орбитальной энергии этих 10 комет во время их прохождения планетной системой вблизи Солнца.

1. Introduction

The present paper is a continuation of a recent paper (Sekanina 1966a), giving original orbits for four comets and future orbits for seven comets. The orbits are included in the General Catalogue of Original and Future Comet Orbits (Sekanina 1966b), except the future orbit of Comet 1905 VI which requires a correction because too large a step of integration that was chosen and possibly a considerable interpolation error in the course of the integration procedure when Cowell's method was applied. The catalogue comprises values of the semi-major axis of original orbits for 81 comets and those of future orbits for 70 comets. For the investigation of the total-energy changes during a single revolution of nearly parabolic comets round the Sun, both original and future orbits should be known. The present paper includes future orbits for ten of the eleven comets, for which only the original orbits are known and included in the catalogue, the eleventh being Comet 1882 II, belonging to a group of "old comets" (Kreutz's group) with the aphelion distance of not more than some 170 AU from the Sun, and having, therefore, nothing common with the problem of the existence of Oort's cloud of comets.

2. Method of computation. Accuracy

A slightly modified method to that applied in the foregoing paper was used here. The comet's definitive orbit was reduced to a 40-day standard date close to the originally given date of osculation by means of Cowell's method, and then Makover's method of integration of perturbations in the barycentric system of co-ordinates was applied, after the reduc-

tion of the orbit to the barycentre. The basic formula is of the form

$$(1) \quad \frac{d}{dw} \left(\frac{1}{a_b} \right) \Delta w = -2\gamma r \left(T' + S' \frac{er}{p} \sin v \right) \frac{\cos^2 \frac{1}{2}v}{\cos^2 \frac{1}{2}w} \Delta w,$$

w is the auxiliary anomaly, used as independent variable, S' and T' are the components of the perturbation accelerations by the planets, v the true anomaly, p and e the parameter of orbit and eccentricity of the osculating orbit, respectively, and γ the auxiliary-anomaly coefficient.

Since only the fifth- and higher-order differences have been omitted in the process of integration of perturbations, comparatively high accuracy is reached, in spite of large values of $d(1/a)/dw$ resulting at smaller heliocentric distances. If the integration of barycentric perturbations begins at a distance not closer than 0.8 AU to the Sun, the error involved should not be higher than $\pm 5 \cdot 10^{-6} (\text{AU})^{-1}$.

The computations consisted of three stages, as follows:

(1) The determination of an osculating orbit at a 40-day standard date close to the date of osculation, excluding, however, heliocentric distances less than 0.8 AU for stages 2 and 3 of the integration procedure. We took the same planets into account, as did the author of the definitive orbit. If the definitive orbit was given for an osculation date identical with the standard date, and of a corresponding distance greater than 0.8 AU from the Sun, this stage of computation was omitted.

(2) The determination of barycentric perturbations in the reciprocal semi-major axis produced by the

Table 1
Osculating orbital elements for 10 comets

Comet	T_{osc}	T	ω_{1950}	Ω_{1950}	i_{1950}	q	e
1863 I	1863 Jan. 15.0 UT	1863 Feb. 3-99197 UT	74.4620	118.1145	85.3574	0.794736	1.000050
1882 I	1882 July 14.0 UT	1882 June 11-02963 UT	208.9889	205.8916	73.8033	0.060763	0.999995
1905 VI	1906 Jan. 30.0 UT	1905 Dec. 22-79634 UT	89.8575	287.0127	126.4404	1.296296	1.000185
1910 III	1910 Sep. 6.0 UT	1910 Sep. 16-78194 UT	50.9642	290.0844	121.0529	1.948024	0.999808
1941 VIII	1941 Sep. 3.0 ET	1941 Sep. 3-18425 ET	85.3285	256.8621	94.5188	0.874788	1.000243
1944 I	1944 Jan. 31.0 ET	1944 Jan. 12-18133 ET	32.9723	57.9099	136.1954	0.874700	1.002649
1954 V	1955 Oct. 20.0 ET	1954 Mar. 24-00978 ET	73.7692	320.6476	123.9259	4.496796	1.001517
1955 IV	1955 Sep. 10.0 UT	1955 July 11-54210 UT	13.2237	302.7629	50.0289	1.427445	0.994123
1957 III	1957 May 2.0 UT	1957 Apr. 8-03117 UT	308.7808	215.1591	119.9495	0.316062	1.000230
1957 V	1957 Aug. 30.0 ET	1957 Aug. 1-43750 ET	40.3122	67.6249	93.9397	0.354924	0.999351

five outer planets and the reduction to their barycentre.

(3) The determination of barycentric perturbations produced by the inner planets, and the reduction to their barycentre. Mercury was generally omitted, Mars has been taken into account only since 1920.

The rectangular co-ordinates of the five outer planets were taken from the tables by Eckert, Brouwer and Clemence (1951), those of the Earth-Moon barycentre and of Venus from the tables by Herget (1953, 1955) and those for Mars from the tables of the H. M. Nautical Almanac Office (1933, 1939).

3. Results

The results of the computations are given in the form of tables. The ten comets studied are as follows:

- Comet 1863 I (Bruhns)
- Comet 1882 I (Wells)
- Comet 1905 VI (Brooks)
- Comet 1910 III (Metcalf)
- Comet 1941 VIII (van Gent)
- Comet 1944 I (van Gent-Peltier-Daimaca)
- Comet 1954 V (Abell)
- Comet 1955 IV (Bakharev-Macfarlane-Krienke)
- Comet 1957 III (Arend-Roland)
- Comet 1957 V (Mrkos)

Table 1 comprises the initial osculating elements of the ten comets for the computations of barycentric perturbations. Tables 2 to 11 include the computations of perturbations by the outer planets, for each of the ten comets studied. The individual columns give: the auxiliary anomaly, w , the true anomaly, v , the comet's heliocentric distance, r , the respective date in U.T. or E.T., the corresponding perturbations in $d(1/a_b)/dw$ in units of the sixth decimal of $(AU)^{-1}$

and the resulting perturbations in the barycentric reciprocal semi-major axis. For the period before 1925 the moments are given in U.T. as well, not in G.M.T. The effect of the inner planets is briefly summarized in Table 12. The data are interpolated from more detailed original perturbation schemes with the auxiliary anomaly as independent variable. The first column gives the time distance from the epoch of osculation, $t - T_{osc}$, in days, the following columns list the total effect of perturbations in $1/a_b$ of the inner planets denoted in the heading of each column (in AU^{-1}). Some details concerning the method of treatment are given in Table 13, namely, the auxiliary-anomaly coefficient, γ , the step of integration in auxiliary anomaly, Δw , and the number of integration steps, N , the two latter for both the outer and the inner planets, separately.

Some remarks should be added to the respective orbits.

The definitive orbit of Comet 1863 I was computed by von Flotow (1902), Venus, Earth, Mars, Jupiter and Saturn having been taken into account. Cowell's method was used for the conversion of the osculation date of February 2 to January 15, 1863. A change of $1/a$ from -0.000059 to -0.000063 is considerably lower than the error involved.

The definitive orbit of Comet 1882 I was derived by von Rebeur-Paschwitz (1887). He mentioned only very small planetary perturbations though the observations covered an arc of nearly 320° and extended to distances of more than $1.7 AU$. He gave no osculation date for his elements, the latter being referred to the epoch of July 14, 1882, in the present paper. At the end of 1888 the comet approached Uranus to a distance of $8 AU$.

The definitive orbit of Comet 1905 VI was determined by Mihajlov (1924). He applied the perturbations

Table 2 Perturbations of 1863 I by outer planets

w	v	r	Date U.T.	Perturbations in $[d(1/a) : dw] \cdot \Delta w$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b$ (au^{-1})
				Jupiter	Saturn	Uranus	Neptune	Pluto	
— 8·4171	— 36·6428	0·88188	1863 Jan. 15·0000	377·64	154·25	— 43·37	— 50·97	— 27·08	0·0000000
— 5·9171	— 26·1850	0·83772	21·2016	163·73	— 90·07	— 170·91	67·74	— 32·72	0·0001826
— 3·4171	— 15·2899	0·80906	27·1269	— 95·02	— 364·21	— 296·39	200·70	— 34·02	— 0·0001432
— 0·9171	— 4·1251	0·79577	Feb. 1·8934	— 347·87	— 603·66	— 385·81	315·30	— 29·64	— 0·0009739
1·5829	7·1145	0·79781	7·6175	— 540·24	— 746·23	— 412·65	380·00	— 20·10	— 0·0021872
4·0829	18·2258	0·81518	13·4150	— 637·87	— 761·91	— 371·60	379·73	— 7·81	— 0·0035754
6·5829	29·0192	0·84797	19·4022	— 640·07	— 665·21	— 280·51	322·34	4·08	— 0·0049186
9·0829	39·3374	0·89627	25·6976	— 573·69	— 502·25	— 169·52	231·97	13·10	— 0·0060545
11·5829	49·0655	0·96030	Mar. 4·4223	— 475·24	— 324·94	— 66·37	135·74	18·24	— 0·0069102
14·0829	58·1339	1·04028	11·7013	— 374·88	— 170·84	12·58	53·19	19·80	— 0·0074920
16·5829	66·5133	1·13654	19·6652	— 289·73	— 56·97	63·05	— 6·96	18·83	— 0·0078522
19·0829	74·2070	1·24944	28·4508	— 225·22	15·85	88·71	— 44·50	16·47	— 0·0080574
21·5829	81·2412	1·37944	Apr. 7·2031	— 179·76	55·33	96·43	— 63·73	13·59	— 0·0081671
24·0829	87·6563	1·52706	18·0762	— 148·92	71·46	93·00	— 70·17	10·77	— 0·0082257
26·5829	93·5009	1·69289	30·2355	— 128·12	73·16	83·73	— 68·71	8·30	— 0·0082621
29·0829	98·8259	1·87761	May 13·8594	— 113·63	67·03	72·19	— 63·01	6·25	— 0·0082929
31·5829	103·6821	2·08200	29·1410	— 102·87	57·45	60·49	— 55·50	4·64	— 0·0083261
34·0829	108·1174	2·30692	June 15·2909	— 94·19	47·01	49·72	— 47·63	3·40	— 0·0083649
36·5829	112·1762	2·55333	July 4·5393	— 86·65	37·12	40·36	— 40·19	2·47	— 0·0084093
39·0829	115·8990	2·82233	26·1395	— 79·70	28·41	32·49	— 33·55	1·78	— 0·0084581
41·5829	119·3220	3·11511	Aug. 19·3706	— 73·09	21·09	26·01	— 27·81	1·27	— 0·0085098
44·0829	122·4774	3·43303	Sept. 15·5417	— 66·69	15·13	20·76	— 22·96	0·90	— 0·0085626
46·5829	125·3939	3·77757	Oct. 15·9962	— 60·45	10·37	16·54	— 18·93	0·63	— 0·0086151
49·0829	128·0967	4·15039	Nov. 19·1169	— 54·36	6·66	13·17	— 15·59	0·44	— 0·0086659
51·5829	130·6081	4·55335	Dec. 27·3318	— 48·40	3·80	10·49	— 12·86	0·29	— 0·0087142
54·0829	132·9476	4·98847	1864 Feb. 8·1208	— 42·56	1·64	8·36	— 10·62	0·19	— 0·0087591
56·5829	135·1326	5·45805	Mar. 27·0236	— 36·83	0·03	6·67	— 8·79	0·12	— 0·0088000
59·0829	137·1783	5·96461	May 19·6491	— 31·19	— 1·14	5·32	— 7·29	0·07	— 0·0088366
61·5829	139·0983	6·51097	July 18·6863	— 25·64	— 1·96	4·25	— 6·06	0·03	— 0·0088684
64·0829	140·9044	7·10027	Sept. 23·9167	— 20·18	— 2·51	3·40	— 5·05	0·01	— 0·0088952
66·5829	142·6073	7·73603	Dec. 8·2296	— 14·89	— 2·85	2·73	— 4·23	— 0·01	— 0·0089170
69·0829	144·2163	8·42216	1865 Mar. 2·6401	— 9·90	— 3·03	2·19	— 3·54	— 0·02	— 0·0089338
71·5829	145·7398	9·16308	June 5·3100	— 5·46	— 3·09	1·75	— 2·98	— 0·03	— 0·0089458
74·0829	147·1853	9·96371	Sept. 19·5737	— 1·92	— 3·05	1·41	— 2·51	— 0·03	— 0·0089536
76·5829	148·5596	10·82961	1866 Jan. 16·9685	0·39	— 2·93	1·13	— 2·11	— 0·03	— 0·0089583
79·0829	149·8685	11·76705	May 31·2713	1·31	— 2·74	0·91	— 1·78	— 0·03	— 0·0089612
81·5829	151·1175	12·78312	Oct. 29·5431	1·05	— 2·51	0·73	— 1·51	— 0·03	— 0·0089634
84·0829	152·3114	13·88585	1867 Apr. 18·1835	0·17	— 2·24	0·58	— 1·27	— 0·03	— 0·0089659
86·5829	153·4546	15·08438	Oct. 27·9962	— 0·70	— 1·94	0·46	— 1·07	— 0·03	— 0·0089690
89·0829	154·5511	16·38914	1868 June 2·2711	— 1·13	— 1·61	0·37	— 0·90	— 0·03	— 0·0089723
91·5829	155·6046	17·81206	1869 Feb. 4·8835	— 1·04	— 1·27	0·29	— 0·76	— 0·03	— 0·0089754
94·0829	156·6181	19·36684	Nov. 13·4196	— 0·60	— 0·94	0·23	— 0·63	— 0·02	— 0·0089778
96·5829	157·5948	21·06931	1870 Sept. 30·3314	— 0·10	— 0·62	0·18	— 0·52	— 0·02	— 0·0089794
99·0829	158·5374	22·93774	1871 Oct. 2·1324	0·18	— 0·37	0·14	— 0·43	— 0·02	— 0·0089801
101·5829	159·4483	24·99344	1872 Nov. 25·6450	0·14	— 0·19	0·11	— 0·35	— 0·02	— 0·0089805
104·0829	160·3299	27·26124	1874 Mar. 24·3153	— 0·13	— 0·12	0·08	— 0·28	— 0·02	— 0·0089809
106·5829	161·1842	29·77035	1875 Oct. 3·6179	— 0·28	— 0·12	0·05	— 0·22	— 0·01	— 0·0089814
109·0829	162·0131	32·55518	1877 July 11·5794	0·00	— 0·15	0·03	— 0·17	— 0·01	— 0·0089819
111·5829	162·8185	35·65662	1879 Aug. 3·4614	— 0·06	— 0·15	0·01	— 0·13	— 0·01	— 0·0089822
114·0829	163·6020	39·12344	1881 Dec. 30·6603	— 0·09	— 0·10	— 0·00	— 0·10	— 0·01	— 0·0089825
116·5829	164·3651	43·01430	1884 Oct. 29·9047	0·00	— 0·03	— 0·01	— 0·07	— 0·01	— 0·0089827
119·0829	165·1093	47·40014	1888 Mar. 4·8629	— 0·07	— 0·01	— 0·02	— 0·04	— 0·01	— 0·0089828
121·5829	165·8358	52·36749	1892 Feb. 25·3301	— 0·04	— 0·02	— 0·03	— 0·03	— 0·00	— 0·0089830
124·0829	166·5459	58·02274	1896 Nov. 28·2367	— 0·01	— 0·05	— 0·02	— 0·01	— 0·00	— 0·0089831
126·5829	167·2408	64·49784	1902 Aug. 24·8440	— 0·01	— 0·02	— 0·02	— 0·00	— 0·00	— 0·0089831
129·0829	167·9215	71·95811	1909 Aug. 12·6793	— 0·01	— 0·02	— 0·01	— 0·00	— 0·00	— 0·0089832
131·5829	168·5890	80·61285	1918 Feb. 26·0672	— 0·01	— 0·00	— 0·01	0·00	— 0·00	— 0·0089832
134·0829	169·2443	90·73020	1928 Sept. 22·6041	— 0·01	— 0·01	— 0·01	— 0·00	— 0·00	— 0·0089832
136·5829	169·8883	102·65820	1941 Dec. 16·7549	— 0·01	— 0·01	— 0·00	— 0·01	0·00	— 0·0089833
139·0829	170·5218	116·85517	1958 Sept. 23·1619	— 0·01	— 0·01	— 0·00	— 0·01	0·00	— 0·0089833

Table 3
Perturbations of 1882 I by outer planets

w	v	r	Date U.T.	Perturbations in $\frac{d(1/a)}{dw} \cdot \Delta w$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b$ (au^{-1})
				Jupiter	Saturn	Uranus	Neptune	Pluto	
40-7302	152-4778	1-07381	1882 July 14-0000	1164-38	971-91	-296-57	608-37	45-18	0-0000000
43-2302	154-1561	1-21502	20-3806	855-71	726-53	-222-37	457-93	34-46	0-0021554
45-7302	155-6689	1-36815	27-7079	632-44	548-39	-168-86	348-34	26-53	0-0037628
48-2302	157-0403	1-53393	Aug. 5-0930	469-47	417-61	-129-75	267-58	20-60	0-0049703
50-7302	158-2900	1-71315	14-6603	349-50	320-57	-100-79	207-41	16-13	0-0058833
53-2302	159-4343	1-90674	25-5493	260-47	247-86	-79-09	162-10	12-72	0-0065772
55-7302	160-4867	2-11568	Sept. 6-9170	193-94	192-87	-62-66	127-66	10-10	0-0071069
58-2302	161-4587	2-34109	20-9402	143-89	150-92	-50-07	101-24	8-08	0-0075124
60-7302	162-3598	2-58420	Oct. 6-8192	106-04	118-67	-40-34	80-79	6-50	0-0078235
63-2302	163-1982	2-84640	24-7808	77-27	93-68	-32-76	64-84	5-25	0-0080621
65-7302	163-9808	3-12923	Nov. 14-0834	55-32	74-19	-26-79	52-32	4-27	0-0082448
68-2302	164-7136	3-43440	Dec. 7-0215	38-54	58-90	-22-05	42-40	3-48	0-0083843
70-7302	165-4018	3-76385	1883 Jan. 1-9323	25-67	46-84	-18-28	34-51	2-86	0-0084901
73-2302	166-0500	4-11973	31-2027	15-82	37-26	-15-24	28-20	2-35	0-0085697
75-7302	166-6620	4-50447	Mar. 5-2781	8-29	29-63	-12-78	23-11	1-94	0-0086286
78-2302	167-2413	4-92082	Apr. 11-6731	2-56	23-52	-10-78	18-99	1-60	0-0086713
80-7302	167-7909	5-37185	May 23-9842	-1-74	18-61	-9-14	15-64	1-33	0-0087014
83-2302	168-3135	5-86108	July 10-9051	-4-91	14-64	-7-79	12-91	1-11	0-0087215
85-7302	168-8115	6-39247	Sept. 3-2456	-7-15	11-44	-6-68	10-67	0-92	0-0087340
88-2302	169-2871	6-97057	Nov. 3-9550	-8-61	8-83	-5-75	8-82	0-77	0-0087405
90-7302	169-7420	7-60054	1884 Jan. 13-1500	-9-37	6-72	-4-98	7-30	0-64	0-0087426
93-2302	170-1781	8-28833	Apr. 2-1507	-9-48	4-99	-4-52	6-04	0-53	0-0087414
95-7302	170-5968	9-04076	July 2-5239	-8-92	3-58	-3-76	5-00	0-45	0-0087382
98-2302	170-9995	9-86575	Oct. 15-1386	-7-63	2-43	-3-34	4-13	0-37	0-0087343
100-7302	171-3875	10-77246	1885 Feb. 12-2356	-5-52	1-49	-2-95	3-40	0-31	0-0087306
103-2302	171-7620	11-77157	June 30-5154	-2-55	0-72	-2-61	2-80	0-26	0-0087281
105-7302	172-1238	12-87561	Dec. 7-2519	1-04	0-11	-2-29	2-29	0-21	0-0087281
108-2302	172-4741	14-09930	1886 June 10-4377	4-25	-0-36	-1-99	1-87	0-18	0-0087308
110-7302	172-8136	15-46011	1887 Jan. 11-9740	5-35	-0-71	-1-63	1-51	0-15	0-0087353
113-2302	173-1431	16-97878	Sept. 20-9195	3-59	-0-92	-1-17	1-21	0-12	0-0087392
115-7302	173-4634	18-68020	1888 July 12-8194	0-84	-0-97	-0-54	0-97	0-10	0-0087408
118-2302	173-7752	20-59437	1889 June 27-1465	-0-66	-0-83	0-18	0-76	0-08	0-0087406
120-7302	174-0790	22-75776	1890 Aug. 15-8974	-0-51	-0-44	0-69	0-58	0-06	0-0087405
123-2302	174-3754	25-21500	1891 Dec. 24-4075	0-29	0-17	0-76	0-44	0-05	0-0087415
125-7302	174-6650	28-02123	1893 Aug. 11-4816	0-43	0-72	0-52	0-31	0-04	0-0078435
128-2302	174-9482	31-24517	1895 Aug. 3-9821	-0-21	0-71	0-26	0-21	0-03	0-0087451
130-7302	175-2256	34-97337	1898 Jan. 3-0943	0-19	0-18	0-07	0-13	0-02	0-0087458
133-2302	175-4976	39-31603	1900 Dec. 28-6114	-0-02	-0-14	-0-02	0-06	0-02	0-0087460
135-7302	175-7645	44-41519	1904 Sept. 16-7842	0-14	-0-07	-0-06	0-00	0-01	0-0087460
138-2302	176-0267	50-45650	1909 May 26-6281	0-01	0-09	-0-05	-0-04	0-01	0-0087460
140-7302	176-2847	57-68619	1915 May 24-1727	0-01	-0-01	-0-02	-0-07	0-00	0-0087460
143-2302	176-5387	66-43656	1923 Mar. 1-2210	0-07	0-06	0-01	-0-07	-0-00	0-0087459
145-7302	176-7891	77-16459	1933 May 30-1714	0-02	-0-02	0-02	-0-03	-0-00	0-0087460
148-2302	177-0361	90-51259	1947 Mar. 11-2816	0-03	-0-02	0-00	0-04	-0-00	0-0087460
150-7302	177-2802	107-40612	1966 Feb. 21-4420	-0-00	0-00	0-00	0-03	0-00	0-0087460

by Venus to Neptune for the osculation date of February 12, 1906. The conversion of osculation from this data to January 30, 1906 changed the reciprocal semi-major axis for not more than a unit in the seventh decimal of $(\text{AU})^{-1}$. The future orbit is here computed anew (see Section 1) and found much

closer to a parabola. At the end of October, 1906, the comet was as close to Jupiter as 1.7 AU.

The definitive orbit of Comet 1910 III was given by Viaro (1936, 1938), applying the perturbations by Jupiter only. The reduction from the osculation date of September 16 to September 6, 1910, changed the

Table 4
Perturbations of 1905 VI by outer planets

w	v	r	Date U.T.	Perturbations in $\frac{d(1/a)}{dw} \cdot \Delta w$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b$ (au^{-1})
				Jupiter	Saturn	Uranus	Neptune	Pluto	
13-9285	33-9631	1-41720	1906 Jan. 30-0000	333-84	35-34	-53-50	88-34	10-48	0-0000000
16-4285	39-6880	1-46515	Feb. 6-4847	252-50	76-37	-36-51	56-19	8-15	0-0003868
18-9285	45-2482	1-52147	14-2892	168-69	107-83	-20-50	26-24	5-83	0-0007098
21-4285	50-6305	1-58638	22-4700	88-06	129-41	-6-31	-0-02	3-64	0-0009614
23-9285	55-8258	1-66014	Mar. 3-0868	14-81	141-73	5-56	-21-72	1-70	0-0011396
26-4285	60-8281	1-74305	12-2035	-48-41	146-02	14-90	-38-58	0-07	0-0012471
28-9285	65-6343	1-83546	21-8888	-100-39	143-83	21-77	-50-75	-1-23	0-0012900
31-4285	70-2443	1-93774	Apr. 1-2168	-141-10	136-79	26-39	-58-68	-2-22	0-0012765
33-9285	74-6598	2-05032	12-2681	-171-35	126-42	29-07	-63-01	-2-91	0-0012154
36-4285	78-8847	2-17370	24-1303	-192-48	114-07	30-18	-64-42	-3-35	0-0011159
38-9285	82-9239	2-30841	May 6-8996	-206-15	100-81	30-07	-63-59	-3-59	0-0009860
41-4285	86-7836	2-45506	20-6817	-214-06	87-44	29-07	-61-15	-3-66	0-0008331
43-9285	90-4708	2-61432	June 4-5932	-217-90	74-57	27-45	-57-61	-3-62	0-0006630
46-4285	93-9930	2-78694	20-7634	-219-15	62-56	25-45	-53-40	-3-48	0-0004802
48-9285	97-3579	2-97374	July 8-3359	-218-95	51-64	23-24	-48-85	-3-29	0-0002879
51-4285	100-5733	3-17565	27-4707	-217-60	41-92	20-97	-44-22	-3-06	0-0000886
53-9285	103-6471	3-39369	Aug. 17-3469	-213-55	33-40	18-72	-39-67	-2-81	-0-0001149
56-4285	106-5871	3-62901	Sept. 9-1654	-201-36	26-04	16-56	-35-34	-2-55	-0-0003163
58-9285	109-4009	3-88286	Oct. 4-1521	-170-36	19-78	14-54	-31-29	-2-30	-0-0005016
61-4285	112-0956	4-15666	31-5621	-112-58	14-50	12-69	-27-56	-2-07	-0-0006459
63-9285	114-6784	4-45199	Nov. 30-6842	-43-74	10-10	11-00	-24-18	-1-84	-0-0007273
66-4285	117-1558	4-77058	1907 Jan. 2-8462	2-67	6-47	9-49	-21-13	-1-63	-0-0007511
68-9285	119-5343	5-11442	Feb. 8-4215	16-92	3-52	8-14	-18-42	-1-44	-0-0007466
71-4285	121-8198	5-48569	Mar. 20-8365	13-38	1-15	6-95	-16-01	-1-27	-0-0007393
73-9285	124-0180	5-88688	May 4-5800	5-38	-0-73	5-90	-13-89	-1-12	-0-0007394
76-4285	126-1344	6-32074	June 23-2142	-1-49	-2-19	4-99	-12-02	-0-98	-0-0007477
78-9285	128-1738	6-79043	Aug. 17-3876	-5-99	-3-29	4-19	-10-39	-0-85	-0-0007619
81-4285	130-1411	7-29948	Oct. 17-8509	-8-37	-4-08	3-51	-8-97	-0-74	-0-0007796
83-9285	132-0407	7-85190	Dec. 25-4769	-9-16	-4-60	2-91	-7-73	-0-65	-0-0007987
86-4285	133-8768	8-45226	1908 Mar. 11-2833	-8-89	-4-90	2-41	-6-65	-0-56	-0-0008176
88-9285	135-6532	9-10577	June 5-4625	-7-95	-4-99	1-97	-5-71	-0-49	-0-0008356
91-4285	137-3736	9-81839	Sept. 10-4170	-6-61	-4-89	1-60	-4-90	-0-42	-0-0008518
93-9285	139-0414	10-59697	Dec. 28-8036	-5-08	-4-60	1-28	-4-19	-0-37	-0-0008659
96-4285	140-6599	11-44939	1909 May 1-5890	-3-53	-4-13	1-01	-3-58	-0-32	-0-0008777
98-9285	142-2320	12-38479	Sept. 19-1195	-2-07	-3-48	0-78	-3-05	-0-27	-0-0008870
101-4285	143-7607	13-41380	1910 Feb. 26-2084	-0-80	-2-66	0-59	-2-59	-0-24	-0-0008939
103-9285	145-2485	14-54881	Aug. 28-2483	0-19	-1-73	0-43	-2-18	-0-20	-0-0008985
106-4285	146-6979	15-80438	1911 Mar. 26-3545	0-81	-0-82	0-29	-1-83	-0-17	-0-0009010
108-9285	148-1114	17-19767	Nov. 23-5503	1-00	-0-11	0-18	-1-52	-0-15	-0-0009021
111-4285	149-4910	18-74907	1912 Aug. 30-0094	0-75	0-24	0-09	-1-25	-0-13	-0-0009025
113-9285	150-8389	20-48288	1913 July 22-3735	0-16	0-21	0-02	-1-02	-0-11	-0-0009030
116-4285	152-1571	22-42831	1914 Aug. 8-1760	-0-42	-0-02	-0-04	-0-82	-0-09	-0-0009041
118-9285	153-4473	24-62071	1915 Oct. 31-4092	-0-40	-0-24	-0-08	-0-65	-0-08	-0-0009055
121-4285	154-7114	27-10313	1917 Apr. 15-2958	0-12	-0-33	-0-11	-0-50	-0-06	-0-0009067
123-9285	155-9509	29-92852	1919 Jan. 9-3490	-0-12	-0-25	-0-13	-0-38	-0-05	-0-0009076
126-4285	157-1676	33-16250	1921 Feb. 8-8487	-0-18	-0-10	-0-13	-0-28	-0-04	-0-0009084
128-9285	158-3628	36-88725	1923 Aug. 19-9284	0-09	0-04	-0-12	-0-20	-0-03	-0-0009089
131-4285	159-5380	41-20674	1926 Sept. 19-5706	-0-12	0-08	-0-09	-0-13	-0-02	-0-0009091
133-9285	160-6945	46-25414	1930 July 10-9825	-0-03	-0-01	-0-05	-0-08	-0-02	-0-0009094
136-4285	161-8336	52-20213	1935 Apr. 11-1086	0-03	-0-07	-0-02	-0-03	-0-01	-0-0009095
138-9285	162-9566	59-27800	1941 Apr. 11-5343	0-01	0-01	-0-00	-0-00	-0-01	-0-0009095
141-4285	164-0646	67-78572	1948 Dec. 19-8999	-0-02	-0-03	-0-01	0-01	-0-00	-0-0009096
143-9285	165-1587	78-13930	1958 Dec. 25-5361	0-01	-0-00	-0-01	0-02	-0-00	-0-0009096
146-4285	166-2401	90-91445	1972 Apr. 5-0233	-0-00	-0-00	0-00	0-01	0-00	-0-0009096
148-9285	167-3097	106-93091	1990 Mar. 28-2811	-0-01	-0-01	-0-00	-0-01	0-00	-0-0009096

Table 5
Perturbations of 1910 III by outer planets

w	v	r	Date U.T.	Perturbations in $\frac{d(1/a)}{dw} \cdot \Delta w$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b$ (au^{-1})
				Jupiter	Saturn	Uranus	Neptune	Pluto	
— 3·6807	— 5·5186	1·95255	1910 Sept. 6·0000	82·27	— 29·85	— 23·82	40·83	1·87	0·0000000
— 0·6807	— 1·0210	1·94818	14·7902	64·27	— 21·33	— 27·80	47·99	2·57	0·0000687
2·3193	3·4784	1·94982	23·5714	44·00	— 12·13	— 31·04	53·90	3·20	0·0001307
5·3193	7·9718	1·95748	Oct. 2·3830	22·24	— 2·62	— 33·45	58·35	3·75	0·0001839
8·3193	12·4517	1·97121	11·2644	— 0·17	6·82	— 34·94	61·20	4·18	0·0002267
11·3193	16·9106	1·99107	20·2559	— 22·36	15·82	— 35·50	62·39	4·50	0·0002577
14·3193	21·3413	2·01718	29·3991	— 43·51	24·03	— 35·16	61·96	4·69	0·0002762
17·3193	25·7369	2·04968	Nov. 7·7371	— 62·89	31·18	— 33·97	60·01	4·76	0·0002817
20·3193	30·0912	2·08876	17·3156	— 79·87	37·06	— 32·05	56·71	4·71	0·0002745
23·3193	34·3981	2·13465	27·1830	— 94·00	41·54	— 29·52	52·29	4·55	0·0002552
26·3193	38·6523	2·18760	Dec. 7·3909	— 104·99	44·56	— 26·52	46·99	4·30	0·0002246
29·3193	42·8490	2·24793	17·9954	— 112·74	46·14	— 23·21	41·07	3·98	0·0001843
32·3193	46·9839	2·31600	29·0574	— 117·27	46·37	— 19·72	34·81	3·59	0·0001357
35·3193	51·0534	2·39222	1911 Jan. 9·6436	— 118·76	45·37	— 16·20	28·44	3·18	0·0000805
38·3193	55·0545	2·47708	21·8276	— 117·50	43·32	— 12·76	22·18	2·74	0·0000203
41·3193	58·9847	2·57112	Feb. 3·6912	— 113·84	40·40	— 9·50	16·20	2·30	— 0·0000430
44·3193	62·8421	2·67495	17·3255	— 108·19	36·82	— 6·49	10·66	1·87	— 0·0001081
47·3193	66·6254	2·78927	Mar. 3·8328	— 100·97	32·76	— 3·79	5·64	1·46	— 0·0001733
50·3193	70·3338	2·91489	19·3286	— 92·61	28·41	— 1·42	1·23	1·08	— 0·0002375
53·3193	73·9667	3·05269	Apr. 4·9436	— 83·49	23·94	0·59	— 2·56	0·74	— 0·0002996
56·3193	77·5243	3·20372	22·8269	— 73·97	19·49	2·26	— 5·72	0·44	— 0·0003588
59·3193	81·0070	3·36913	May 12·1486	— 64·36	15·16	3·59	— 8·27	0·18	— 0·0004144
62·3193	84·4154	3·55025	June 2·1045	— 54·91	11·06	4·60	— 10·25	— 0·04	— 0·0004661
65·3193	87·7506	3·74858	24·9206	— 45·84	7·24	5·33	— 11·70	— 0·22	— 0·0005134
68·3193	91·0140	3·96584	July 19·8589	— 37·29	3·77	5·81	— 12·68	— 0·37	— 0·0005564
71·3193	94·2069	4·20402	Aug. 16·2246	— 29·39	0·66	6·08	— 13·25	— 0·48	— 0·0005950
74·3193	97·3312	4·46536	Sept. 15·3752	— 22·21	— 2·08	6·16	— 13·47	— 0·56	— 0·0006292
77·3193	100·3886	4·75249	Oct. 18·7309	— 15·80	— 4·44	6·09	— 13·41	— 0·62	— 0·0006594
80·3193	103·3810	5·06841	Nov. 24·7888	— 10·17	— 6·43	5·90	— 13·11	— 0·65	— 0·0006857
83·3193	106·3107	5·41662	1912 Jan. 5·1398	— 5·32	— 8·07	5·61	— 12·63	— 0·66	— 0·0007084
86·3193	109·1797	5·80118	Feb. 20·4900	— 1·24	— 9·38	5·26	— 12·02	— 0·66	— 0·0007279
89·3193	111·9901	6·22685	Apr. 12·6887	2·10	— 10·38	4·87	— 11·30	— 0·64	— 0·0007446
92·3193	114·7443	6·69922	June 10·7631	4·71	— 11·08	4·44	— 10·53	— 0·62	— 0·0007588
95·3193	117·4444	7·22491	Aug. 16·9642	6·63	— 11·49	4·01	— 9·72	— 0·59	— 0·0007709
98·3193	120·0928	7·81175	Nov. 1·8258	7·88	— 11·59	3·57	— 8·91	— 0·55	— 0·0007812
101·3193	122·6917	8·46912	1913 Jan. 29·2430	8·47	— 11·30	3·14	— 8·10	— 0·51	— 0·0007902
104·3193	125·2433	9·20829	May 11·5755	8·41	— 10·44	2·73	— 7·32	— 0·47	— 0·0007978
107·3193	127·7498	10·04290	Sept. 7·7872	7·71	— 8·57	1·56	— 6·58	— 0·43	— 0·0008046
110·3193	130·2135	10·98961	1914 Jan. 25·6346	6·38	— 4·79	1·97	— 5·89	— 0·39	— 0·0008093
113·3193	132·6364	12·06889	July 9·9273	4·46	2·27	1·64	— 5·25	— 0·35	— 0·0008095
116·3193	135·0208	13·30615	1915 Jan. 22·8895	2·11	11·59	1·33	— 4·67	— 0·31	— 0·0008030
119·3193	137·3687	14·73323	Sept. 16·6719	— 0·25	15·23	1·05	— 4·13	— 0·27	— 0·0007914
122·3193	139·6822	16·39045	1916 June 30·0861	— 1·67	10·19	0·80	— 3·61	— 0·24	— 0·0007826
125·3193	141·9632	18·32947	1917 June 17·6782	— 0·49	4·18	0·58	— 3·06	— 0·21	— 0·0007797
128·3193	144·2138	20·61734	1918 Aug. 29·3274	2·57	0·79	0·39	— 2·42	— 0·19	— 0·0007787
131·3193	146·4358	23·34235	1920 Mar. 1·6774	0·94	— 0·47	0·23	— 1·73	— 0·17	— 0·0007786
134·3193	148·6312	26·62265	1922 Feb. 1·9227	— 0·60	— 0·55	0·09	— 1·14	— 0·16	— 0·0007807
137·3193	150·8018	30·61918	1924 July 31·8618	0·51	— 0·12	— 0·02	— 0·74	— 0·14	— 0·0007821
140·3193	152·9459	35·55578	1927 Nov. 17·8666	— 0·22	0·28	— 0·10	— 0·49	— 0·08	— 0·0007826
143·3193	155·0759	41·75106	1932 Apr. 30·8632	0·03	0·22	— 0·12	— 0·33	— 0·01	— 0·0007830
146·3193	157·1829	49·67096	1938 June 30·3980	0·03	— 0·11	— 0·05	— 0·20	— 0·00	— 0·0007833
149·3193	159·2721	60·01866	1947 Apr. 15·3134	0·03	0·05	0·08	— 0·08	— 0·01	— 0·0007834
152·3193	161·3453	73·89555	1960 Apr. 9·4196	0·06	0·06	— 0·00	0·01	— 0·01	— 0·0007833

Table 6
Perturbations of 1941 VIII by outer planets

w	v	r	Date E.T.	Perturbations in $\frac{d(1/a)}{dw} \cdot \Delta w$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b$ (au^{-1})
				Jupiter	Saturn	Uranus	Neptune	Pluto	
—0·0785	—0·3139	0·87479	1941 Sept. 3·0000	2147·14	1070·48	364·61	—123·98	33·41	0·0000000
2·4215	9·6645	0·88104	8·8840	2059·82	1053·43	354·51	—146·03	29·91	0·0034607
4·9215	19·5075	0·90064	14·8602	1709·36	901·97	299·79	—148·33	22·80	0·0065597
7·4215	29·0865	0·93367	21·0247	1188·46	659·15	215·75	—133·01	13·83	0·0089396
9·9215	38·2934	0·98025	27·4754	617·15	383·60	122·41	—106·16	4·89	0·0104216
12·4215	47·0469	1·04057	Oct. 4·3126	99·18	127·68	37·15	—75·03	—2·57	0·0110133
14·9215	55·2932	1·11486	11·6404	—303·21	—75·77	—29·49	—45·55	—7·86	0·0108578
17·4215	63·0045	1·20341	19·5676	—571·32	—215·33	—74·25	—21·29	—10·94	0·0101625
19·9215	70·1748	1·30656	28·2085	—717·53	—295·35	—99·03	—3·47	—12·18	0·0091374
22·4215	76·8149	1·42473	Nov. 6·6845	—769·38	—328·28	—108·29	8·25	—12·12	0·0079581
24·9215	82·9473	1·55840	17·1249	—757·11	—328·47	—106·97	15·01	—11·25	0·0067520
27·4215	88·6019	1·70810	28·6687	—706·77	—308·62	—99·34	18·13	—9·98	0·0056007
29·9215	93·8127	1·87446	Dec. 11·4660	—637·64	—278·36	—88·59	18·84	—8·57	0·0045488
32·4215	98·6153	2·05818	25·6795	—562·33	—244·29	—76·85	18·07	—7·21	0·0036151
34·9215	103·0449	2·26004	1942 Jan. 10·4870	—487·91	—210·43	—65·41	16·51	—5·96	0·0028027
37·4215	107·1352	2·48091	28·0831	—417·30	—179·02	—54·95	14·61	—4·88	0·0021061
39·9215	110·9179	2·72179	Feb. 16·6817	—350·71	—151·07	—45·75	12·64	—3·97	0·0015166
42·4215	114·4224	2·98375	Mar. 10·5195	—287·29	—126·85	—37·88	10·76	—3·21	0·0010256
44·9215	117·6752	3·26802	Apr. 3·8582	—227·06	—106·21	—31·26	9·05	—2·59	0·0006251
47·4215	120·7007	3·57595	30·9893	—172·19	—88·78	—25·75	7·56	—2·09	0·0003063
49·9215	123·5207	3·90903	May 31·2378	—126·08	—74·13	—21·21	6·27	—1·68	0·0000584
52·4215	126·1547	4·26893	July 3·9673	—90·83	—61·78	—17·48	5·17	—1·35	—0·0001320
54·9215	128·6203	4·65751	Aug. 10·5860	—65·85	—51·32	—14·42	4·25	—1·09	—0·0002784
57·4215	130·9332	5·07682	Sept. 21·5534	—48·83	—42·38	—11·93	3·48	—0·88	—0·0003922
59·9215	133·1074	5·52915	Nov. 7·3885	—37·21	—34·66	—9·89	2·84	—0·72	—0·0004818
62·4215	135·1555	6·01707	Dec. 29·6787	—29·01	—27·97	—8·21	2·32	—0·58	—0·0005530
64·9215	137·0888	6·54343	1943 Feb. 26·0913	—22·94	—22·20	—6·84	1·88	—0·47	—0·0006098
67·4215	138·9174	7·11140	May 2·3861	—18·22	—17·32	—5·71	1·53	—0·38	—0·0006550
69·9215	140·6502	7·72455	July 14·4316	—14·42	—13·31	—4·78	1·23	—0·31	—0·0006907
72·4215	142·2954	8·38689	Oct. 4·2226	—11·28	—10·13	—4·00	0·99	—0·26	—0·0007187
74·9215	143·8602	9·10291	1944 Jan. 3·9034	—8·65	—7·68	—3·36	0·80	—0·21	—0·0007405
77·4215	145·3514	9·87766	Apr. 15·7934	—6·43	—5·86	—2·81	0·64	—0·17	—0·0007573
79·9215	146·7747	10·71688	Aug. 9·4199	—4·57	—4·52	—2·35	0·51	—0·14	—0·0007701
82·4215	148·1357	11·62704	Dec. 17·5571	—3·03	—3·53	—1·96	0·40	—0·12	—0·0007797
84·9215	149·4391	12·61548	1945 May 13·2730	—1·79	—2·79	—1·63	0·32	—0·10	—0·0007867
87·4215	150·6894	13·69058	Oct. 25·9885	—0·85	—2·22	—1·34	0·25	—0·08	—0·0007918
89·9215	151·8906	14·86192	1946 May 1·5483	—0·19	—1·77	—1·10	0·19	—0·07	—0·0007954
92·4215	153·0463	16·14045	Nov. 30·3100	0·18	—1·40	—0·89	0·15	—0·05	—0·0007978
94·9215	154·1600	17·53882	1947 July 30·2541	0·28	—1·09	—0·71	0·11	—0·04	—0·0007995
97·4215	155·2347	19·07162	1948 May 1·1228	0·14	—0·82	—0·57	0·08	—0·04	—0·0008008
99·9215	156·2731	20·75577	1949 Mar. 12·5941	—0·14	—0·59	—0·45	0·06	—0·03	—0·0008020
102·4215	157·2779	22·61101	1950 Mar. 9·5032	—0·39	—0·39	—0·35	0·05	—0·02	—0·0008031
104·9215	158·2515	24·66045	1951 Apr. 30·1255	—0·41	—0·23	—0·27	0·04	—0·02	—0·0008041
107·4215	159·1959	26·93129	1952 Aug. 23·5418	—0·21	—0·11	—0·21	0·03	—0·01	—0·0008048
109·9215	160·1134	29·45572	1954 Mar. 5·1120	—0·17	—0·04	—0·16	0·02	—0·01	—0·0008053
112·4215	161·0056	32·27209	1955 Dec. 16·0971	—0·23	—0·01	—0·12	0·01	—0·01	—0·0008056
114·9215	161·8744	35·42632	1958 Jan. 16·4817	—0·10	—0·02	—0·09	0·01	—0·01	—0·0008059
117·4215	162·7213	38·97381	1960 July 2·0746	—0·05	—0·05	—0·07	0·01	—0·00	—0·0008061
119·9215	163·5479	42·98190	1963 May 30·9961	—0·08	—0·08	—0·04	0·00	—0·00	—0·0008062
122·4215	164·3556	47·53308	1966 Nov. 17·7134	—0·07	—0·07	—0·03	0·00	—0·00	—0·0008064
124·9215	165·1457	52·72928	1971 Jan. 15·8609	—0·03	—0·04	—0·02	0·00	—0·00	—0·0008065
127·4215	165·9193	58·69768	1976 Jan. 28·2053	—0·03	—0·04	—0·01	—0·01	0·00	—0·0008066
129·9215	166·6777	65·59859	1982 Mar. 19·3031	—0·02	—0·02	—0·01	—0·01	0·00	—0·0008067
132·4215	167·4220	73·63645	1989 Oct. 8·7139	—0·02	—0·02	—0·01	—0·02	0·00	—0·0008067
134·9215	168·1531	83·07531	1999 Mar. 5·1430	—0·01	—0·01	—0·01	—0·02	0·00	—0·0008068
137·4215	168·8720	94·26103	2011 Jan. 4·7702	—0·01	—0·01	—0·01	—0·02	—0·00	—0·0008069

Table 7
Perturbations of 1944 I by outer planets

w	v	r	Date E.T.	Perturbations in $\frac{d(1/a)}{dw} \cdot dw$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b$ (au^{-1})
				Jupiter	Saturn	Uranus	Neptune	Pluto	
7-8140	30-5588	0-94007	1944 Jan. 31-0000	-277-21	-978-08	-353-24	385-26	-14-44	0-0000000
10-3140	39-6993	0-98886	Feb. 6-5013	142-32	-774-26	-302-46	439-70	-5-79	-0-0008626
12-8140	48-3760	1-05145	13-4060	445-00	-542-44	-233-97	438-29	1-43	-0-0010447
15-3140	56-5395	1-12809	20-8194	617-95	-325-81	-163-24	397-60	6-56	-0-0007081
17-8140	64-1658	1-21908	28-8515	678-63	-149-23	-100-66	335-95	9-58	-0-0000402
20-3140	71-2518	1-32479	Mar. 8-6182	658-46	-20-68	-51-14	268-33	10-84	0-0007905
22-8140	77-8105	1-44566	18-2430	589-70	63-10	-15-44	204-58	10-86	0-0016567
25-3140	83-8657	1-58220	28-8578	498-50	110-83	8-13	149-77	10-11	0-0024755
27-8140	89-4483	1-73497	Apr. 9-6045	402-83	132-38	22-18	105-53	8-97	0-0032015
30-3140	94-5928	1-90463	22-6369	313-34	136-57	29-36	71-45	7-70	0-0038167
32-8140	99-3345	2-09192	May 7-1222	235-21	130-28	31-93	46-12	6-46	0-0043201
35-3140	103-7086	2-29767	23-2433	170-11	118-38	31-61	27-86	5-32	0-0047206
37-8140	107-7486	2-52281	June 10-2010	117-66	104-12	29-63	15-04	4-34	0-0050314
40-3140	111-4858	2-76838	30-2169	76-48	89-48	26-83	6-29	3-50	0-0052670
42-8140	114-9490	3-03553	July 22-5361	44-86	75-59	23-73	0-48	2-81	0-0054410
45-3140	118-1647	3-32557	Aug. 16-4313	21-07	63-02	20-64	-3-23	2-24	0-0055657
47-8140	121-1565	3-63992	Sept. 13-2063	3-54	51-98	17-74	-5-46	1-78	0-0056516
50-3140	123-9460	3-98019	Oct. 14-2011	-9-05	42-48	15-11	-6-70	1-41	0-0057074
52-8140	126-5525	4-34816	Nov. 17-7972	-17-76	34-43	12-79	-7-25	1-12	0-0057403
55-3140	128-9931	4-74583	Dec. 26-4243	-23-43	27-67	10-77	-7-36	0-88	0-0057558
57-8140	131-2833	5-17541	1945 Feb. 7-5675	-26-70	22-04	9-03	-7-19	0-69	0-0057587
60-3140	133-4370	5-63938	Mar. 27-7764	-28-02	17-38	7-56	-6-85	0-54	0-0057527
62-8140	135-4664	6-14050	May 20-6755	-27-65	13-54	6-30	-6-42	0-43	0-0057409
65-3140	137-3826	6-68188	July 19-9766	-25-69	10-38	5-24	-5-94	0-33	0-0057259
67-8140	139-1955	7-26700	Sept. 25-4937	-22-07	7-79	4-35	-5-45	0-26	0-0057103
70-3140	140-9140	7-89977	Dec. 10-1607	-16-50	5-67	3-60	-4-98	0-20	0-0056965
72-8140	142-5461	8-58459	1946 Mar. 5-0523	-8-64	3-95	2-97	-4-52	0-15	0-0056872
75-3140	144-0990	9-32645	June 8-4099	1-46	2-55	2-45	-4-10	0-11	0-0056852
77-8140	145-5792	10-13098	Sept. 23-6728	12-11	1-42	2-00	-3-71	0-08	0-0056925
80-3140	146-9924	11-00459	1947 Jan. 22-5154	19-03	0-53	1-63	-3-36	0-06	0-0057079
82-8140	148-3440	11-95459	June 7-8936	18-46	-0-17	1-32	-3-04	0-04	0-0057258
85-3140	149-6388	12-98930	Nov. 9-1020	12-26	-0-70	1-06	-2-75	0-03	0-0057393
87-8140	150-8811	14-11830	1948 May 1-8436	5-50	-1-06	0-84	-2-49	0-02	0-0057455
90-3140	152-0749	15-35263	Nov. 16-3174	1-06	-1-26	0-66	-2-27	0-01	0-0057458
92-8140	153-2239	16-70504	1949 June 30-3283	-0-86	-1-30	0-51	-2-07	-0-00	0-0057428
95-3140	154-3312	18-19034	1950 Mar. 15-4250	-1-03	-1-14	0-38	-1-90	-0-01	0-0057390
97-8140	155-4000	19-82583	1951 Jan. 5-0752	-0-32	-0-76	0-27	-1-75	-0-01	0-0057358
100-3140	156-4330	21-63182	Dec. 10-8910	0-47	-0-14	0-18	-1-62	-0-01	0-0057339
102-8140	157-4328	23-63224	1953 Jan. 5-9179	0-75	0-63	0-10	-1-49	-0-01	0-0057334
105-3140	158-4016	25-85552	1954 Apr. 5-0133	0-31	1-21	0-04	-1-33	-0-02	0-0057336
107-8140	159-3417	28-33563	1955 Sept. 15-3419	-0-28	1-16	-0-01	-1-03	-0-02	0-0057336
110-3140	160-2550	31-11344	1957 May 25-0358	0-03	0-60	-0-04	-0-35	-0-02	0-0057335
112-8140	161-1435	34-23848	1959 May 21-0796	0-47	0-06	-0-07	0-91	-0-02	0-0057343
115-3140	162-0087	37-77135	1961 Sept. 25-5144	-0-13	-0-14	-0-08	1-84	-0-01	0-0057358
117-8140	162-8524	41-78681	1964 July 13-0971	0-16	-0-08	-0-06	1-51	-0-01	0-0057373
120-3140	163-6759	46-37807	1967 Nov. 19-6198	-0-09	0-06	-0-02	0-82	-0-01	0-0057385
122-8140	164-4808	51-66266	1971 Dec. 8-2053	0-08	0-08	0-04	0-35	-0-01	0-0057391
125-3140	165-2682	57-79066	1976 Nov. 15-0732	0-07	-0-04	0-08	0-11	-0-00	0-0057395
127-8140	166-0394	64-95645	1982 Dec. 15-5727	0-07	0-06	0-04	0-00	0-00	0-0057397
130-3140	166-7955	73-41585	1990 July 13-7931	-0-01	-0-02	-0-00	-0-03	0-00	0-0057398
132-8140	167-5376	83-51180	2000 Feb. 3-9850	0-03	0-03	-0-01	-0-03	0-00	0-0057397
135-3140	168-2667	95-71389	2012 May 4-7208	0-02	0-02	0-01	-0-01	-0-00	0-0057397

Table 8
Perturbations of 1954 V by outer planets

$w = v$	r	Date E.T.	Perturbations in $\frac{d(1/a)}{dw} \cdot \Delta w$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b$ (au^{-1})
			Jupiter	Saturn	Uranus	Neptune	Pluto	
$^{\circ}$								
65-5935	6-36596	1955 Oct. 20-0000	-19-95	-5-66	-0-38	-3-05	-0-13	0-0000000
67-5935	6-51376	Nov. 17-0457	-21-66	-5-45	-0-51	-3-05	-0-14	-0-0000300
69-5935	6-67089	Dec. 16-4348	-22-92	-5-23	-0-64	-3-04	-0-15	-0-0000615
71-5935	6-83800	1956 Jan. 16-2870	-23-35	-4-98	-0-76	-3-02	-0-16	-0-0000937
73-5935	7-01580	Feb. 17-7344	-22-41	-4-72	-0-87	-2-98	-0-17	-0-0001255
75-5935	7-20508	Mar. 22-9238	-19-48	-4-43	-0-98	-2-93	-0-17	-0-0001553
77-5935	7-40670	Apr. 28-0183	-14-12	-4-14	-1-08	-2-87	-0-18	-0-0001807
79-5935	7-62163	June 5-1998	-6-74	-3-83	-1-17	-2-80	-0-18	-0-0001994
81-5935	7-85091	July 15-6714	1-17	-3-51	-1-26	-2-72	-0-19	-0-0002099
83-5935	8-09571	Aug. 27-6606	7-47	-3-19	-1-34	-2-62	-0-19	-0-0002129
85-5935	8-35733	Oct. 12-4231	10-80	-2-86	-1-42	-2-52	-0-19	-0-0002107
87-5935	8-63720	Nov. 30-2467	11-18	-2-53	-1-49	-2-42	-0-19	-0-0002063
89-5935	8-93692	1957 Jan. 21-4567	9-60	-2-21	-1-56	-2-30	-0-19	-0-0002022
91-5935	9-25826	Mar. 18-4212	7-14	-1-88	-1-63	-2-19	-0-18	-0-0001999
93-5935	9-60323	May 17-5588	4-58	-1-56	-1-69	-2-06	-0-18	-0-0001997
95-5935	9-97406	July 21-3464	2-31	-1-26	-1-77	-1-94	-0-18	-0-0002016
97-5935	10-37326	Sept. 29-3295	0-52	-0-96	-1-85	-1-81	-0-17	-0-0002052
99-5935	10-80365	Dec. 14-1342	-0-78	-0-67	-1-95	-1-69	-0-17	-0-0002100
101-5935	11-26843	1958 Mar. 6-4814	-1-60	-0-40	-2-09	-1-56	-0-16	-0-0002156
103-5935	11-77123	June 4-2045	-2-01	-0-15	-2-27	-1-43	-0-15	-0-0002215
105-5935	12-31615	Sept. 10-2712	-2-08	0-08	-2-52	-1-31	-0-15	-0-0002276
107-5935	12-90790	Dec. 26-8088	-1-86	0-28	-2-86	-1-18	-0-14	-0-0002334
109-5935	13-55185	1959 Apr. 24-1376	-1-44	0-47	-3-27	-1-06	-0-13	-0-0002390
111-5935	14-25419	Sept. 1-8100	-0-88	0-62	-3-58	-0-95	-0-12	-0-0002442
113-5935	15-02203	1960 Jan. 24-6609	-0-25	0-75	-3-13	-0-84	-0-12	-0-0002486
115-5935	15-86365	July 3-8699	0-34	0-84	-1-35	-0-73	-0-11	-0-0002510
117-5935	16-78863	Dec. 31-0409	0-82	0-89	0-49	-0-63	-0-10	-0-0002506
119-5935	17-80824	1961 July 21-3019	1-07	0-91	1-04	-0-53	-0-09	-0-0002486
121-5935	18-93565	1962 Mar. 6-4346	1-03	0-89	0-83	-0-45	-0-08	-0-0002462
123-5935	20-18648	Nov. 20-0409	0-65	0-82	0-51	-0-36	-0-07	-0-0002443
125-5935	21-57927	1963 Sept. 10-7601	0-05	0-71	0-25	-0-29	-0-06	-0-0002432
127-5935	23-13618	1964 Aug. 13-5555	-0-40	0-55	0-07	-0-22	-0-05	-0-0002429
129-5935	24-88389	1965 Sept. 7-0950	-0-11	0-36	-0-03	-0-16	-0-04	-0-0002430
131-5935	26-85477	1966 Dec. 3-2627	0-65	0-14	-0-09	-0-10	-0-03	-0-0002427
133-5935	29-08835	1968 May 14-8551	0-34	-0-07	-0-11	-0-05	-0-03	-0-0002423
135-5935	31-63337	1970 Jan. 27-5399	-0-23	-0-19	-0-11	-0-01	-0-02	-0-0002426
137-5935	34-55042	1972 Feb. 6-1948	0-08	-0-11	-0-10	0-02	-0-02	-0-0002430
139-5935	37-91565	1974 July 11-8053	0-10	0-15	-0-07	0-05	-0-01	-0-0002429
141-5935	41-82580	1977 June 19-1998	-0-00	0-15	-0-04	0-07	-0-01	-0-0002427
143-5935	46-40526	1981 Jan. 23-0610	-0-05	-0-06	-0-01	0-08	-0-01	-0-0002427
145-5935	51-81620	1985 July 8-9303	0-07	-0-02	0-01	0-08	-0-00	-0-0002426
147-5935	58-27322	1991 Feb. 12-3932	0-06	0-06	0-03	0-08	-0-00	-0-0002424
149-5935	66-06523	1998 Apr. 3-4837	0-01	-0-03	0-02	0-06	0-00	-0-0002423
151-5935	75-58868	2007 July 7-9088	0-01	0-01	0-00	0-03	0-00	-0-0002422
153-5935	87-39976	2019 Oct. 8-6946	0-01	0-02	-0-01	0-00	0-00	-0-0002422

$(1/a)$ value from 0-000096 to 0-000099 (AU) $^{-1}$. At the beginning of 1915 the comet was close to Saturn. The approach shortened the semi-major axis of the orbit; in spite of this, however, its future orbit is a more extended ellipse than its original orbit.

The definitive orbit of Comet 1941 VIII was computed by Pels (1960), considering perturbations

by Venus to Saturn. Cowell's method converted the orbit from the osculation date of September 13 to September 3, 1941, indicating a change of $2 \cdot 10^{-6}$ (AU) $^{-1}$ in the reciprocal semi-major axis. The comet approached Jupiter to 2-5 AU in March, 1942, and the Earth to 0-77 AU at the end of November, 1941.

The definitive orbit of Comet 1944 I was derived

Table 9
Perturbations of 1955 IV by outer planets

w	v	r	Date U.T.	Perturbations in $\frac{d(1/a)}{dw} \cdot \Delta w$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b$ (au^{-1})
				Jupiter	Saturn	Uranus	Neptune	Pluto	
23-0638	44-3973	1-66432	1955 Sept. 10-0000	325-73	-62-38	56-37	16-35	6-27	0-0000000
25-5638	48-8099	1-72026	17-5945	304-78	-45-49	52-04	23-66	5-94	0-0003424
28-0638	53-1154	1-78276	25-5321	278-83	-29-99	46-99	29-38	5-50	0-0006789
30-5638	57-3096	1-85208	Oct. 3-8575	249-69	-16-23	41-52	33-54	5-00	0-0010016
33-0638	61-3900	1-92848	12-6194	218-96	-4-43	35-90	36-25	4-45	0-0013042
35-5638	65-3549	2-01231	21-8701	188-03	5-37	30-38	37-67	3-89	0-0015827
38-0638	69-2037	2-10391	31-6671	157-99	13-20	25-11	37-98	3-34	0-0018343
40-5638	72-9366	2-20368	Nov. 11-0730	129-67	19-20	20-22	37-39	2-82	0-0020577
43-0638	76-5545	2-31206	22-1568	103-65	23-54	15-79	36-10	2-33	0-0022530
45-5638	80-0592	2-42955	Dec. 3-9944	80-27	26-45	11-87	34-28	1-88	0-0024209
48-0638	83-4527	2-55669	16-6699	59-70	28-14	8-46	32-09	1-49	0-0025631
50-5638	86-7377	2-69409	30-2764	41-95	28-84	5-56	29-69	1-14	0-0026814
53-0638	89-9171	2-84241	1956 Jan. 13-9178	26-94	28-74	3-13	27-17	0-84	0-0027782
55-5638	92-9942	3-00241	29-7101	14-51	28-04	1-15	24-63	0-59	0-0028559
58-0638	95-9724	3-17491	Feb. 15-7831	4-45	26-89	-0-45	22-14	0-38	0-0029169
60-5638	98-8552	3-36082	Mar. 5-2827	-3-47	25-42	-1-71	19-75	0-20	0-0029635
63-0638	101-6463	3-56117	25-3733	-9-47	23-76	-2-66	17-49	0-06	0-0029980
65-5638	104-3494	3-77710	Apr. 16-2408	-13-80	21-99	-3-36	15-40	-0-05	0-0030225
68-0638	106-9682	4-00987	May 10-0957	-16-67	20-18	-3-85	13-47	-0-13	0-0030390
70-5638	109-5062	4-26089	June 5-1775	-18-30	18-38	-4-17	11-72	-0-19	0-0030490
73-0638	111-9672	4-53176	July 3-7591	-18-89	16-65	-4-35	10-15	-0-24	0-0030543
75-5638	114-3546	4-82425	Aug. 4-1529	-18-62	14-99	-4-42	8-74	-0-27	0-0030561
78-0638	116-6719	5-14034	Sept. 7-7174	-17-69	13-44	-4-39	7-49	-0-29	0-0030555
80-5638	118-9224	5-48229	Oct. 15-8653	-16-27	12-01	-4-31	6-38	-0-30	0-0030535
83-0638	121-1094	5-85263	Nov. 27-0737	-14-51	10-69	-4-17	5-42	-0-30	0-0030507
85-5638	123-2359	6-25421	1957 Jan. 12-8955	-12-57	9-49	-4-00	4-57	-0-30	0-0030479
88-0638	125-3050	6-69030	Mar. 5-9746	-10-56	8-40	-3-81	3-84	-0-29	0-0030452
90-5638	127-3196	7-16457	May 3-0632	-8-58	7-43	-3-61	3-21	-0-27	0-0030431
93-0638	129-2825	7-68127	July 7-0439	-6-69	6-56	-3-40	2-67	-0-26	0-0030416
95-5638	131-1962	8-24520	Sept. 17-9565	-4-94	5-78	-3-20	2-20	-0-25	0-0030409
98-0638	133-0634	8-86192	Dec. 9-0317	-3-35	5-09	-3-00	1-81	-0-23	0-0030408
100-5638	134-8865	9-53783	1958 Mar. 11-7331	-1-93	4-48	-2-81	1-48	-0-21	0-0030415
103-0638	136-6678	10-28033	June 24-8095	-0-69	3-93	-2-63	1-20	-0-20	0-0030428
105-5638	138-4095	11-09802	Oct. 22-3620	0-37	3-44	-2-45	0-97	-0-18	0-0030447
108-0638	140-1138	12-00094	1959 Mar. 7-9283	1-22	3-00	-2-27	0-78	-0-16	0-0030471
110-5638	141-7827	13-00086	Aug. 11-5920	1-83	2-60	-2-08	0-62	-0-15	0-0030498
113-0638	143-4182	14-11166	1960 Feb. 8-1230	2-15	2-23	-1-84	0-50	-0-13	0-0030527
115-5638	145-0220	15-34975	Sept. 4-1611	2-12	1-87	-1-56	0-40	-0-12	0-0030555
118-0638	146-5961	16-73470	1961 May 5-4566	1-69	1-53	-1-24	0-32	-0-11	0-0030580
120-5638	148-1421	18-28991	1962 Feb. 14-1894	0-87	1-20	-0-93	0-26	-0-09	0-0030598
123-0638	149-6615	20-04359	1963 Jan. 15-3968	-0-12	0-86	-0-68	0-21	-0-08	0-0030605
125-5638	151-1561	22-02994	1964 Feb. 16-5509	-0-63	0-52	-0-48	0-18	-0-07	0-0030603
128-0638	152-6273	24-29072	1965 June 4-3485	0-21	0-19	-0-35	0-16	-0-06	0-0030601
130-5638	154-0765	26-87724	1966 Dec. 25-8021	1-01	-0-10	-0-26	0-15	-0-05	0-0030606
133-0638	155-5050	29-85310	1968 Nov. 14-7675	-0-16	-0-26	-0-19	0-14	-0-03	0-0030608
135-5638	156-9144	33-29772	1971 Mar. 8-1073	-0-01	-0-15	-0-13	0-14	-0-03	0-0030603
138-0638	158-3058	37-31112	1974 Jan. 11-8010	0-20	0-28	-0-08	0-14	-0-02	0-0030605
140-5638	159-6804	42-02035	1977 Aug. 1-4762	0-10	0-22	-0-03	0-13	-0-01	0-0030611
143-0638	161-0395	47-58824	1982 Jan. 24-1150	-0-10	-0-09	0-01	0-13	-0-01	0-0030612
145-5638	162-3842	54-22539	1987 Oct. 15-1341	-0-06	0-06	0-04	0-12	-0-00	0-0030612
148-0638	163-7157	62-20651	1995 Mar. 12-7853	0-00	0-02	0-04	0-10	-0-00	0-0030614
150-5638	165-0351	71-89280	2004 Dec. 5-0668	-0-02	0-06	0-02	0-07	0-00	0-0030616
153-0638	166-3433	83-76214	2017 Dec. 5-4369	-0-02	0-03	-0-01	0-02	0-00	0-0030616

Table 10
Perturbations of 1957 III by outer planets

w	v	r	Date U.T.	Perturbations in $\frac{d(1/a)}{dw} \cdot \Delta w$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b$ (au^{-1})
				Jupiter	Saturn	Uranus	Neptune	Pluto	
17-3300	97-6337	0-72907	1957 May 2-0000	-6635-46	-2689-75	-253-34	-2042-06	-80-96	0-0000000
19-8300	105-3281	0-85944	8-1567	-4557-35	-1570-22	-240-22	-1303-59	-61-99	-0-0095975
22-3300	111-9181	1-00888	15-4556	-3077-60	-895-77	-201-45	-818-71	-45-49	-0-0158904
24-8300	117-5951	1-17799	24-0752	-2071-88	-502-24	-159-73	-511-69	-32-76	-0-0199850
27-3300	122-5182	1-36748	June 3-2076	-1401-33	-276-52	-123-34	-320-28	-23-45	-0-0226548
29-8300	126-8170	1-57812	15-0602	-956-05	-148-33	-94-18	-201-43	-16-82	-0-0244090
32-3300	130-5965	1-81082	28-8591	-658-97	-76-10	-71-72	-127-43	-12-13	-0-0255737
34-8300	133-9415	2-06656	July 14-8507	-458-83	-35-81	-54-74	-81-10	-8-83	-0-0263558
37-3300	136-9206	2-34648	Aug. 2-3058	-322-34	-13-69	-41-98	-51-87	-6-48	-0-0268868
39-8300	139-5899	2-65182	23-5226	-228-02	-1-91	-32-41	-33-28	-4-81	-0-0272508
42-3300	141-9948	2-98398	Sept. 16-8309	-162-03	-4-05	-25-21	-21-37	-3-61	-0-0275021
44-8300	144-1730	3-34451	Oct. 14-5971	-115-34	-6-74	-19-76	-13-69	-2-73	-0-0276767
47-3300	146-1556	3-73514	Nov. 15-2289	-82-00	-7-63	-15-61	-8-71	-2-09	-0-0277981
49-8300	147-9682	4-15779	Dec. 21-1820	-58-05	-7-58	-12-43	-5-46	-1-61	-0-0278826
52-3300	149-6327	4-61460	1958 Jan. 30-9673	-40-76	-7-05	-9-96	-3-35	-1-25	-0-0279411
54-8300	151-1672	5-10792	Mar. 18-1589	-28-25	-6-32	-8-05	-1-97	-0-98	-0-0279813
57-3300	152-5872	5-64042	May 9-4043	-19-20	-5-53	-6-54	-1-08	-0-78	-0-0280085
59-8300	153-9059	6-21502	July 7-4356	-12-67	-4-75	-5-34	-0-51	-0-62	-0-0280265
62-3300	155-1345	6-83501	Sept. 12-0831	-7-98	-4-03	-4-38	-0-15	-0-50	-0-0280380
64-8300	156-2828	7-50405	Nov. 26-2911	-4-66	-3-39	-3-61	-0-08	-0-40	-0-0280450
67-3300	157-3592	8-22623	1959 Feb. 19-1370	-2-35	-2-81	-2-99	-0-21	-0-33	-0-0280488
69-8300	158-3710	9-00615	May 25-8536	-0-80	-2-30	-2-47	-0-28	-0-27	-0-0280505
72-3300	159-3246	9-84896	Sept. 10-8559	-0-16	-1-86	-2-04	-0-31	-0-22	-0-0280509
74-8300	160-2255	10-76044	1960 Jan. 10-7732	-0-66	-1-47	-1-69	-0-32	-0-18	-0-0280506
77-3300	161-0788	11-74715	May 27-4882	-0-79	-1-13	-1-39	-0-32	-0-15	-0-0280499
79-8300	161-8887	12-81646	Oct. 30-1831	-0-64	-0-83	-1-13	-0-30	-0-12	-0-0280493
82-3300	162-6591	13-97676	1961 Apr. 24-3975	-0-29	-0-56	-0-92	-0-28	-0-10	-0-0280490
84-8300	163-3935	15-23757	Nov. 10-0971	-0-18	-0-33	-0-74	-0-26	-0-09	-0-02800491
87-3300	164-0949	16-60975	1962 June 24-7594	-0-63	-0-13	-0-59	-0-24	-0-07	-0-0280498
89-8300	164-7661	18-10575	1963 Mar. 9-4787	-0-90	-0-05	-0-46	-0-21	-0-06	-0-0280509
92-3300	165-4095	19-73985	Dec. 28-0973	-0-80	-0-19	-0-36	-0-19	-0-05	-0-0280522
94-8300	166-0274	21-52851	1964 Nov. 27-3681	-0-38	-0-30	-0-27	-0-17	-0-04	-0-0280532
97-3300	166-6217	23-49082	1965 Dec. 16-1599	-0-10	-0-37	-0-20	-0-16	-0-03	-0-0280538
99-8300	167-1944	25-64894	1967 Mar. 1-7162	-0-24	-0-37	-0-15	-0-14	-0-03	-0-0280544
102-3300	167-7470	28-02880	1968 July 20-9860	-0-34	-0-31	-0-10	-0-12	-0-02	-0-0280551
104-8300	168-2811	30-66083	1970 Feb. 27-0474	-0-12	-0-19	-0-07	-0-11	-0-02	-0-0280556
107-3300	168-7980	33-58094	1972 Jan. 7-6566	-0-05	-0-07	-0-04	-0-09	-0-01	-0-0280557
109-8300	169-2990	36-83182	1974 Mar. 8-9638	-0-09	-0-03	-0-02	-0-08	-0-01	-0-0280557
112-3300	169-7853	40-46443	1976 Sept. 19-4572	-0-03	-0-07	-0-00	-0-07	-0-01	-0-0280557
114-8300	170-2579	44-54014	1979 Sept. 12-2192	-0-08	-0-08	-0-01	-0-06	-0-00	-0-0280558
117-3300	170-7179	49-13327	1983 Mar. 20-6169	-0-01	-0-02	-0-01	-0-04	-0-00	-0-0280558
119-8300	171-1660	54-33464	1987 May 26-6027	-0-04	-0-02	-0-01	-0-03	-0-00	-0-0280558
122-3300	171-6033	60-25617	1992 May 27-8874	-0-04	-0-02	-0-01	-0-02	-0-00	-0-0280558
124-8300	172-0304	67-03707	1998 June 9-3752	-0-02	-0-02	-0-00	-0-00	-0-00	-0-0280559
127-3300	172-4480	74-85235	2005 Oct. 7-4603	-0-01	-0-01	-0-01	-0-01	-0-00	-0-0280559
129-8300	172-8570	83-92458	2014 Oct. 2-1145	-0-01	-0-00	-0-01	-0-02	-0-00	-0-0280559
132-3300	173-2578	94-54044	2025 Nov. 16-2501	-0-00	-0-01	-0-00	-0-02	-0-00	-0-0280560

by Marsden and van Biesbroeck (1963), applying perturbations by Venus to Saturn. The original osculation date of January 11 was converted to January 31, 1944, giving a change of $5 \cdot 10^{-6} (\text{AU})^{-1}$ in $1/a$. Strong perturbations by Jupiter lasted longer

than usual, because the comet remained closer than 7 AU to the planet up to July 1947.

The definitive orbit of Comet 1954 V was established by van Biesbroeck and Marsden (1963) for the osculation date of October 20, 1955, identical with a 40-day

Table 11
Perturbations of 1957 V by outer planets

w	v	r	Date E.T.	Perturbations in $\frac{d(1/a)}{dw} \cdot \Delta w$ (in 10^{-6} au^{-1})					Perturbations in $(1/a)_b (\text{au}^{-1})$
				Jupiter	Saturn	Uranus	Neptune	Pluto	
18.5657	97.6920	0.81919	1957 Aug. 30.0000	-1336.32	-1390.03	188.77	-537.51	-7.24	0.0000000
21.0657	104.9278	0.95563	Sept. 5.8270	-1317.65	-1298.41	172.12	-520.97	-3.25	-0.0030647
23.5657	111.1900	1.11091	13.8414	-1163.58	-1095.57	141.83	-447.46	-1.16	-0.0058431
26.0657	116.6369	1.28564	23.2209	-976.23	-880.08	111.11	-362.92	-0.16	-0.0081793
28.5657	121.4019	1.48053	Oct. 4.1566	-799.55	-690.02	84.77	-286.00	0.28	-0.0100734
31.0657	125.5954	1.69635	16.8556	-648.49	-535.20	63.79	-222.31	0.44	-0.0115835
33.5657	129.3082	1.93399	31.5427	-525.10	-413.91	47.69	-171.91	0.45	-0.0127803
36.0657	132.6150	2.19444	Nov. 17.4638	-426.42	-320.71	35.56	-132.91	0.41	-0.0137291
38.5657	135.5769	2.47882	Dec. 6.8887	-348.13	-249.73	26.52	-103.06	0.34	-0.0144846
41.0657	138.2441	2.78833	29.1143	-285.91	-195.85	19.79	-80.29	0.28	-0.0150899
43.5657	140.6582	3.12437	1958 Jan. 23.4689	-235.99	-154.92	14.79	-62.92	0.22	-0.0155782
46.0657	142.8538	3.48844	Feb. 21.3167	-195.16	-123.77	11.06	-49.62	0.17	-0.0159747
48.5657	144.8596	3.88222	Mar. 26.0626	-160.60	-99.97	8.27	-39.40	0.12	-0.0162981
51.0657	146.6999	4.30759	May 2.1586	-129.66	-81.70	6.18	-31.50	0.09	-0.0165615
53.5657	148.3949	4.76662	June 13.1106	-99.56	-67.55	4.60	-25.36	0.06	-0.0167733
56.0657	149.9621	5.26159	July 30.4862	-67.27	-56.37	3.41	-20.55	0.04	-0.0169376
58.5657	151.4161	5.79505	Sept. 21.9243	-30.27	-47.17	2.51	-16.76	0.02	-0.0170541
61.0657	152.7697	6.36984	Nov. 21.1458	10.60	-39.07	1.82	-13.76	0.01	-0.0171201
63.5657	154.0336	6.98909	1959 Jan. 27.9667	46.47	-31.45	1.29	-11.37	0.00	-0.0171367
66.0657	155.2174	7.65630	Apr. 14.3127	63.19	-24.13	0.89	-9.45	-0.01	-0.0171170
68.5657	156.3292	8.37536	July 9.2371	56.99	-17.53	0.59	-7.90	-0.01	-0.0170840
71.0657	157.3762	9.15064	Oct. 13.9419	39.30	-12.23	0.36	-6.64	-0.02	-0.0170570
73.5657	158.3646	9.98698	1960 Jan. 30.8024	22.11	-8.45	0.18	-5.62	-0.02	-0.0170427
76.0657	159.3000	10.88983	June 1.3974	10.03	-5.98	0.05	-4.78	-0.02	-0.0170393
78.5657	160.1871	11.86531	Oct. 17.5441	2.93	-4.39	-0.05	-4.09	-0.02	-0.0170428
81.0657	161.0304	12.92030	1961 Mar. 22.3416	-0.58	-3.35	-0.13	-3.52	-0.02	-0.0170496
83.5657	161.8336	14.06254	Sept. 14.2217	-1.82	-2.62	-0.18	-3.05	-0.02	-0.0170574
86.0657	162.6002	15.30080	1962 Apr. 1.0118	-1.72	-2.05	-0.21	-2.65	-0.02	-0.0170646
88.5657	163.3333	16.64502	Nov. 12.0109	-0.97	-1.59	-0.24	-2.31	-0.02	-0.0170705
91.0657	164.0356	18.10648	1963 July 25.0824	-0.06	-1.19	-0.25	-2.02	-0.02	-0.0170748
93.5657	164.7095	19.69804	1964 May 9.7684	0.60	-0.83	-0.25	-1.77	-0.02	-0.0170777
96.0657	165.3574	21.43442	1965 Apr. 4.4308	0.77	-0.52	-0.25	-1.52	-0.02	-0.0170796
98.5657	165.9812	23.33249	1966 Apr. 15.4264	0.42	-0.26	-0.23	-1.28	-0.02	-0.0170810
101.0657	166.5828	25.41169	1967 June 19.3251	-0.14	-0.04	-0.21	-1.02	-0.02	-0.0170824
103.5657	167.1639	27.69446	1968 Oct. 24.1852	-0.34	0.11	-0.18	-0.74	-0.02	-0.0170838
106.0657	167.7260	30.20685	1970 May 13.8998	0.15	0.19	-0.14	-0.45	-0.02	-0.0170845
108.5657	168.2705	32.97918	1972 Feb. 26.6377	0.25	0.19	-0.09	-0.19	-0.01	-0.0170845
111.0657	168.7987	36.04695	1974 Mar. 24.4085	-0.14	0.10	-0.04	-0.02	-0.01	-0.0170845
113.5657	169.3117	39.45182	1976 Aug. 19.7911	0.11	-0.02	0.02	0.05	-0.01	-0.0170845
116.0657	169.8107	43.24304	1979 June 11.8794	-0.05	-0.09	0.06	0.05	-0.01	-0.0170844
118.5657	170.2967	47.47898	1982 Sept. 26.5219	0.08	-0.00	0.06	0.02	-0.01	-0.0170844
121.0657	170.7706	52.22930	1986 Aug. 12.9584	-0.04	0.08	0.04	-0.02	-0.00	-0.0170843
123.5657	171.2332	57.57756	1991 Mar. 17.0007	-0.02	-0.02	0.00	-0.04	-0.00	-0.0170843
126.0657	171.6854	63.62453	1996 Sept. 2.9646	0.00	-0.01	-0.01	-0.04	-0.00	-0.0170844
128.5657	172.1279	70.49252	2003 Mar. 23.6526	-0.02	0.02	-0.02	-0.04	0.00	-0.0170844
131.0657	172.5615	78.33087	2011 Feb. 15.8164	-0.00	-0.01	-0.00	-0.03	-0.00	-0.0170845
133.5657	172.9867	87.32316	2020 Sept. 22.7331	-0.00	-0.01	0.01	-0.01	-0.00	-0.0170845

standard date. They applied perturbations by all planets except Mercury and Pluto. Because of the extreme distance of the comet from the inner-planet region, no effect by these planets appeared in the barycentric co-ordinates even in the eighth decimal

of $(1/a)$. Therefore no data on perturbations by the inner planets are presented in Table 12 concerning this comet.

The author of the definitive orbit of Comet 1955 IV is van Houten-Groeneveld (1963a). The perturbations

Table 12
Perturbations by inner planets

$t - T_{osc}$ (days)	Perturbations in $(1/a_b)$ (au^{-1})								
	Comet 1863 I	1882 I	1905 VI	1910 III	1941 VIII	1944 I	1955 IV	1957 III	1957 V
	Planets included V E	V E	V E	V E	V E M	V E M	V E M	V E M	V E M
0	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
5	+ 18	+ 19	- 3	+ 0	- 4	- 0	+ 1	- 22	- 21
10	28	29	6	0	9	+ 0	2	37	35
15	32	32	8	+ 0	13	2	2	49	42
20	29	34	9	- 0	16	3	3	57	45
25	23	34	9	0	19	3	3	63	47
30	+ 15	34	9	0	21	4	3	68	49
40	- 3	34	9	0	27	4	3	74	51
50	15	34	9	1	34	4	2	77	52
60	21	34	10	1	41	5	2	78	52
70	23	34	10	- 0	47	5	1	79	52
80	25	35	11	+ 0	48	4	1	80	51
90	26	35	12	0	44	3	0	80	50
100	27	36	12	1	39	1	+ 0	80	50
120	28	36	11	+ 0	30	0	- 0	81	49
140	29	37	11	- 0	26	1	1	81	49
160	29	37	10	1	24	1	1	81	48
180	27	36	10	1	25	1	1	81	48
200	26	36	10	2	25	1	- 0.0000001	81	48
220	25	36	10	2	25	1		82	48
240	24	36	10	2	24	0		82	48
260	24	37	10	2	24	0		82	48
280	24	37	10	2	24	1		82	48
300	24	+ 0.0000037	10	- 0.0000002	24	1		82	48
340	24		10		24	1		- 0.0000082	- 0.0000048
380	- 0.0000024		- 0.0000010		24	1			
420					- 0.0000024	+ 0.0000001			

by all planets are included and the osculation date is identical with a 40-day standard date.

For Comet 1957 III no computed definitive orbit is known to the author of the present paper. An improved hyperbolical orbit was given by Hasegawa (1957), being probably the best orbit of this comet available at present. No conspicuous perturbations, not included in the Hasegawa elements, can, however, be expected, because of the character of the comet's orbit. Since Marsden (1966) decided, in spite of the absence of any reliable osculating orbit, to compute the backward perturbations for determining a rough value of the original orbit of this comet, the present calculations make it possible to establish the total orbital-energy change for Comet Arend-Roland without knowledge of a reliable osculation orbit. The date of osculation was selected as May 2, 1957, and the resulting future orbit must be considered approximate.

The definitive orbit of Comet 1957 V was studied by Schrutka-Rechtenstamm (1960a, 1960b). The

perturbations by Venus, Earth, Jupiter and Saturn were applied and a 40-day standard date of August 30, 1957, was chosen as the date of osculation.

Table 13
Parameters of the method of treatment

Comet	γ	Outer planets		Inner planets	
		Δw	N	Δw	N
1863 I	4.5	2.5	60	1.5	43
1882 I	11.0	2.5	45	1.5	27
1905 VI	2.5	2.5	55	1.5	38
1910 III	1.5	3.0	53	1.5	47
1941 VIII	4.0	2.5	56	1.5	40
1944 I	4.0	2.5	52	1.5	35
1954 V	1.0	2.0	45	—	—
1955 IV	2.0	2.5	53	1.5	27
1957 III	7.5	2.5	47	1.5	26
1957 V	7.0	2.5	47	1.5	26

Table 14
Future and original orbits, and orbital energy changes for 10 comets (in 10^{-6} au $^{-1}$)

Comet		1863 I	1882 I	1905 VI	1910 III	1941 VIII	1944 I	1954 V	1955 IV	1957 III	1957 V
$(1/a)_{osc}$		— 63	+ 90	— 143	+ 99	— 278	—3028	—337	+4117	— 727	+ 1830
Outer planets	Perturbations	—8983	+8746	— 910	—783	— 807	+5740	—242	+3062	—28056	—17085
	Reduction to barycentre	+9800	—8071	+1409	+958	+1260	—4714	+602	—2926	+28190	+18336
Inner planets	Perturbations	— 2	+ 4	— 1	— 0	— 2	+ 0	0	— 0	—8	— 5
	Reduction to barycentre	+ 14	+ 12	+ 8	+ 6	+ 15	+ 9	+ 2	+ 7	+ 20	+ 17
$(1/a_b)_{fut}$		+ 766	+ 781	+ 363	+280	+ 188	—1993	+ 25	+4260	— 581	+ 3093
$(1/a_b)_{orig}$		+ 528	+ 144	+ 638	+472	+ 82	—2360	+142	+4354	— 42	+ 2038
$O - F$		— 238	— 637	+ 275	+192	— 106	— 367	+117	+ 94	+ 539	— 1055
ϵ_d		$\pm$ 60	$\pm$ 20	$\pm$ 50	$\pm$ 5	$\pm$ 7	$\pm$ 381	$\pm$ 18	$\pm$ 46	—	$\pm$ 17
Author		B, vHG	B, vHG	M	B, vHG	P	M, vB	vB, M	vHG	M	vHG

Abbreviations: B, vHG — Bilo, van Houten-Groeneveld (1960)
M — Mihajlov (1924)
P — Pels-Kluyver (1960)

M, vB — Marsden, van Biesbroeck (1963)
vB, M — van Biesbroeck, Marsden (1963)
vHG — van Houten-Groeneveld (1963b)

4. Conclusions

The summary of the results is given in Table 14. For each comet it gives: the osculating value of the reciprocal semi-major axis, the sum of perturbations in $(1/a)$ and the reduction to barycentre for both the outer planets and the inner planets and the resulting future value of $(1/a_b)$. Then follow the so-called catalogue value of the original reciprocal semi-major axis, taken from the General Catalogue of Original and Future Comet Orbits (Sekanina 1966b), and the total energy-change, $O - F$, being positive if the comet is accelerated when passing through the planetary system, and negative, if the comet is decelerated. The root-mean-square error included in the $(1/a)$ value of the definitive orbit and the author of the original orbit from which the catalogue value of $(1/a_b)_{orig}$ was derived are added. As is seen, there is no systematic course of $(O - F)$, 5 comets having been accelerated and 5 comets decelerated. The total energy changes of comet orbits will be discussed in detail in another paper in the near future.

The computations were carried out on Zuse Z23 computers in the ČKD Computing Centre, Prague, and in the State Research Institute for Engine Construction, Prague. Finally, the author would like to thank Messrs. Černíkovský, Hubený, Rádšich and Vojtíšek and Miss Wiesnerová for their help

in tape-punching extensive numerical data for the digital computers.

REFERENCES

- van Biesbroeck G., Marsden B. G., 1963, AJ 68, 212.
Bilo E. H., van Houten-Groeneveld I., 1960, BAN 15, 155.
Eckert W. J., Brouwer D., Clemence G. M., 1951, Astr. Papers Vol. 12.
von Flotow A., 1902, AN 160, 217.
Hasegawa I., 1957, IAU Circ No. 1619.
Herget P., 1953, Astr. Papers Vol. 14.
—, 1955, Astr. Papers Vol. 15, Part III.
van Houten-Groeneveld I., 1963a, BAN 17, 223.
—, 1963b, BAN 17, 240.
Marsden B. G., 1966, private communication.
Marsden B. G., van Biesbroeck G., 1963, AJ 68, 235.
Mihajlov A., 1924, AŽ 1, 56.
Nautical Almanac Office, 1933, Planetary Co-ordinates for the Years 1800—1940.
Nautical Almanac Office, 1939, Planetary Co-ordinates for the Years 1940—1960.
Pels G., 1960, BAN 15, 127.
Pels-Kluyver H. A., 1960, BAN 15, 163.
von Rebeur-Paschwitz E., 1887, AN 117, 281.
Schrutka-Rechtenstamm G., 1960a, IAU Circ No. 1740.
—, 1960b, Mitt. Univ. Sternwarte Wien 11, 35.
Sekanina Z., 1966a, BAC 17, 67.
—, 1966b, Publ. Astr. Inst. Charles Univ. Prague, No. 48.
Viario M., 1936, Capodimonte Contr. Ser. 2, No. 12.
—, 1938, Mem. Mat. Fis. Nat. Soc. Ital. Ser. 3, 24, 63.