

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
**CASE FILE
COPY**

Technical Report 32-1296

*Card Format for Optical and Radar
Planetary Data*

Douglas A. O'Handley

**JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA**

May 1, 1968

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Report 32-1296

*Card Format for Optical and Radar
Planetary Data*

Douglas A. O'Handley

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

May 1, 1968

TECHNICAL REPORT 32-1296

Copyright © 1968
Jet Propulsion Laboratory
California Institute of Technology
Prepared Under Contract No. NAS 7-100
National Aeronautics & Space Administration

Preface

The work described in this report was performed by the Ephemeris Working Group. The group includes personnel from the U.S. Naval Observatory, the U.S. Naval Weapons Laboratory, the National Aeronautics and Space Administration, and the Jet Propulsion Laboratory.

Six conferences were devoted to discussions and formulation of a card format for planetary range data and optical data.

The participants at one or more of these conferences included:

Dr. Raynor L. Duncombe, U.S. Naval Observatory
Dr. R. Glenn Hall, U.S. Naval Observatory
Dr. Alan D. Fiala, U.S. Naval Observatory
Mr. Thomas C. Van Flandern, U.S. Naval Observatory
Mr. Paul Janiczek, U.S. Naval Observatory
Mr. William J. Klepczynski, U.S. Naval Observatory
Mr. P. Kenneth Seidelmann, U.S. Naval Observatory

Dr. Charles Cohen, U.S. Naval Weapons Laboratory
Dr. Claus Oesterwinter, U.S. Naval Weapons Laboratory
Mr. Clyde Hubbard, U.S. Naval Weapons Laboratory

Mr. Lloyd Carpenter, Goddard Space Flight Center
Dr. Raymond Wilson, NASA Headquarters
Mr. Glenn Reiff, NASA Headquarters
Dr. William Brunk, NASA Headquarters

Dr. Paul Herget, Cincinnati Observatory

Dr. Irwin I. Shapiro, Massachusetts Institute of Technology
Mr. Michael E. Ash, Lincoln Laboratory
Mr. William B. Smith, Lincoln Laboratory

Dr. William G. Melbourne, Jet Propulsion Laboratory
Dr. Charles Lawson, Jet Propulsion Laboratory
Mr. Carleton B. Solloway, Jet Propulsion Laboratory
Dr. Roger Broucke, Jet Propulsion Laboratory
Dr. J. Derral Mulholland, Jet Propulsion Laboratory
Dr. Douglas A. O'Handley, Jet Propulsion Laboratory

Foreword

The card formats described herein are the result of considerable experience in the handling of current data sets. As new data are obtained, it may be necessary to alter a data field or add a code. When such an alteration or addition becomes necessary, a letter to the author of this report would be appreciated. Appropriate communications will then be originated to obtain a fast resolution of the problem. Because a large quantity of data has already been incorporated in these formats, altering of a format becomes a serious matter that should be considered by the Ephemeris Working Group.

Acknowledgment

The information presented in this report evolved as the result of a combined effort by personnel from the National Aeronautics and Space Administration, the U.S. Naval Observatory, the U.S. Naval Weapons Laboratory, and the Jet Propulsion Laboratory.

Contents

I. Introduction	1
II. Optical Card	1
A. Planet Number—Columns 1 Through 4	1
B. Julian Date—Columns 5 Through 21	2
C. Observatory Codes—Columns 22 Through 24	2
D. Instrument—Column 25	4
E. Catalogue Code—Columns 26 Through 28	4
F. Observation Parameters—Columns 29 Through 33 and 50	4
G. Right Ascension—Columns 34 Through 42	9
H. Equinox—Columns 43 and 60	9
I. Right Ascension (Comparison)—Columns 44 Through 49	9
J. Declination—Columns 51 Through 59	9
K. Declination (Comparison)—Columns 61 Through 65	9
L. Year—Columns 73 Through 76	9
M. Source Number—Columns 77 Through 80	9
III. Radar Card	9
A. Planet Number—Columns 1 Through 4	9
B. Julian Date—Columns 5 Through 21	10
C. Observatory Codes—Columns 22 Through 24 and 26 Through 28	10
D. Type of Observation—Column 29	10
E. Range—Columns 30 Through 42	10
F. Standard Deviation (Range)—Columns 43 Through 47	11
G. Observations—Column 48	11
H. Doppler—Columns 49 Through 57	11
I. Standard Deviation (Doppler)—Columns 58 Through 62	11
J. Frequency Offset—Columns 63 Through 66	11
K. Frequency—Columns 67 Through 72	11
L. Year—Columns 73 Through 76	11
M. Source Number—Columns 77 Through 80	11

Contents (contd)

IV. Modified Card Format	12
A. Modified Card Format—Columns 44 Through 49 and 61 Through 65	12
B. Modified Card Format—Columns 66 Through 67 and 68 Through 69	12
References	12
Appendix. Card Bibles	13

Tables

1. List of observatories	2
2. Catalogue abbreviation and information	4
3. Six-inch transit circle observers	7
4. Clamp designation for six-inch transit circle	8
5. Limb codes for meridian observatories	8
6. Radar transmitter and receiver codes	10
7. Source codes for JPL-punched radar observations	11

Figures

A-1. Optical card—revision 2	14
A-2. Radar data card—revision 3	15
A-3. Optical card for USNO Mercury optical observations— revision 2 (modified)	16

Abstract

The Ephemeris Working Group grew out of informal discussions by users and producers of optical and radar observations of the moon and planets. Its first meeting was held in February 1967 at the Naval Weapons Laboratory. Subsequent meetings were held in May 1967 at the U.S. Naval Observatory, in November 1967 at the U.S. Naval Observatory, in January 1968 at the Jet Propulsion Laboratory, in April 1968 at the Naval Weapons Laboratory, and in June 1968 at the U.S. Naval Observatory. These meetings have provided a useful opportunity for the exchange of ideas on such problems as the analysis and interpretation of observations, the discussion of methods, and the presentation of results. One of the results of the discussions of the Ephemeris Working Group was the desirability of a common format for all observational data in machine-readable form. The following report delineates the card formats to be used in the exchange of data.

Card Format for Optical and Radar Planetary Data

I. Introduction

The observations of the bodies in the solar system both by optical and radar techniques have been collected by the various agencies. Because of the number of observations and the varied formats in which the data have been collected, it is necessary to provide a single card format which allows insertion of the maximum amount of information. The following discussion is an attempt to provide a single card format.

In this report, an attempt is made to provide a format for optical data that will be uniform from 1750 to the present. A separate format is provided for some of the data reconstructed from equations of condition. The card format for planetary range data represents a further attempt to originate a uniform data card for future use. This also includes the possibility of receiving radar echoes from Pluto and other types of radar data.

The list of observatories covered by the codes adopted for the data cards is perhaps not as complete as it could be. However, this document, being a preliminary guideline, is felt to be as comprehensive as need be for present purposes. Additional sources of information will undoubtedly expand the list of radar observatories. The ultimate goal of the Ephemeris Working Group is to assign unique codes to all entries in the data cards in conformity (where possible) with international usage. Once assigned, these

codes will be permanent. Other codes will be added only after consideration by the Ephemeris Working Group.

This report is sectioned according to the type of observation and then the column-by-column codes. The data card formats are shown in the Appendix.

II. Optical Card

An optical data card is shown in the Appendix (Fig. A-1). The optical data card displays the following information.

A. Planet Number—Columns 1 Through 4

The following code is used to identify planets:

P001 Mercury¹
P002 Venus
P004 Mars
P005 Jupiter
P006 Saturn
P007 Uranus
P008 Neptune
P009 Pluto
P010 Sun
P011 Moon

¹P = planet.

Although the moon is not a planet, the code 11 has been commonly used to designate it and, therefore, this practice will be continued. The four columns allow enough space to include International Astronomical Union (IAU) asteroid designations and, with the proper prefix, can also designate natural and artificial satellites.

B. Julian Date—Columns 5 Through 21

The data listed in columns 5 through 21 represent the published time tags to be attached to the optical observations. The data are not corrected to ephemeris time. It should be noted that the decimal point is implied between columns 11 and 12. To conserve space for necessary information, no decimal points are included on this card format.

These values are the epoch of observation in most instances except for transit circle observations from the U.S. Naval Observatory. In this case, the decimal portion should be derived from consideration of the right ascension of the object.

C. Observatory Codes—Columns 22 Through 24

The observatories listed in Table 1 represent a merging of information obtained from various sources.²

²Information obtained from the "Minor Planet Circulars," Cincinnati Observatory, and Table III of "The Astronomical Papers of the American Ephemeris," Vol. XX, Part 3.

Table 1. List of observatories

Number	Location	Altitude, m	Longitude			Latitude			Number	Location	Altitude, m	Longitude			Latitude		
			h	m	s	°	'	"				h	m	s	°	'	"
119	Abastumani	1580	−02	51	18.08	+41	45	18.2	779	David Dunlap Observatory	244	+05	17	41.3	+43	51	46
8	Algiers	345	−00	12	08.53	+36	48	04.8		Durham	107	+00	06	19.75	+54	46	06.2
210	Alma Ata	1450	−05	07	49.76	+43	11	16.9	18	Düsseldorf	46	−00	27	02.69	+51	12	25.0
30	Arcetri	184	−00	45	01.30	+43	45	14.4									
66	Athens	110	−01	34	52.06	+37	58	19.7									
6	Barcelona	415	−00	08	30.20	+41	24	59.3	136	Engelhardt, Kazan	121	−03	15	15.74	+55	50	20.2
57	Belgrade (post-1931)	253	−01	22	03.20	+44	48	13.2	689	Flagstaff, USNO	2310	+07	27	02.1	+35	11	28.0
660	Berkeley	94	+08	09	02.91	+37	52	23.5	517	Geneva (1901)	407	−00	24	36.61	+46	11	59.3
	Berlin (1835–1913)	47	−00	53	34.80	+52	30	16.7	760	Goethe Link Observatory	300	+05	45	34.86	+39	32	57.7
16	Besancon	312	−00	23	57.42	+47	14	59.8	000	Greenwich	47	00	00	00.00	+51	28	38.2
74	Bloemfontein	1490	−01	44	57	−29	05	45	29	Hamburg–Bergedorf	41	−00	40	57.74	+53	28	46.9
520	Bonn	62	−00	28	23.18	+50	43	45.0	24	Heidelberg–Königstuhl	567	−00	34	53.13	+49	23	55.2
999	Bordeaux	73	+00	02	06.60	+44	50	07	218	Hyderabad	554	−05	13	48.98	+17	25	54.3
821	Bosque Alegre, Argentina	1250	+04	18	11.20	−31	35	53	80	Istanbul	65	−01	55	52	+41	00	45
73	Bucharest	83	−01	44	23.20	+44	24	49.4		Jena	165	−00	46	20.22	+50	55	34.9
53	Budapest (pre-1933)	474	−01	15	54.00	+47	29	58.0	76	Johannesburg–Hartebeespoort	1220	−01	51	30.44	−25	46	22.4
802	Cambridge, Harvard	24	+04	44	31.05	+42	22	47.6	78	Johannesburg	1741	−01	52	07.00	−26	11	14.0
51	Cape, South Africa	10	−01	13	54.38	−33	56	02.5	21	Karlsruhe (1955)	128	−00	33	32.51	+49	01	26.6
	Cerro El Roble, Chile (Maksutov)	2000	+04	44	38	−32	59	00	135	Kazan City Observatory	79	−03	16	29.03	+55	47	23.9
765	Cincinnati (post-1873)	247	+05	37	41.40	+39	08	19.8	85	Kiev	184	−02	02	00.56	+50	27	11.8
35	Copenhagen	14	−00	50	18.69	+55	41	12.6	186	Kitab	658	−04	27	31.7	+39	08	01.7
822	Cordoba	434	+04	16	47.16	−31	25	16.4	58	Königsberg	24	−01	21	58.97	+54	42	50.5
55	Cracow	221	−01	19	50.30	+50	03	52.0	539	Kremsmünster	384	−00	56	31.58	+48	03	23.1
									377	Kyoto–Kwasan	234	−09	03	10.40	+34	59	40.8
									839	La Plata	17	+03	51	43.72	−34	54	30.3

Table 1 (contd)

Number	Location	Altitude, m	Longitude			Latitude			Number	Location	Altitude, m	Longitude			Latitude		
			h	m	s	°	'	"				h	m	s	°	'	"
13	Leiden	6	—00	17	56.15	+52	09	19.8	983	San Fernando	30	+00	24	49.30	—36	27	42.0
81	Leiden Station, Johannesburg								804	Santiago	580	+04	42	45.09	—33	33	44.2
534	Leipzig	119	—00	49	33.92	+51	20	05.9	128	Saratov							
662	Lick, Mt. Hamilton	1283	+08	06	34.93	+37	20	25.3	338	Shanghai, Zo-Se	100	—08	04	44.75	+31	05	47.6
690	Lowell Observatory	2210	+07	26	44.6	+35	12	30.5	94	Simeis	346	—02	15	59.38	+44	24	11.6
39	Lund	34	—00	52	44.97	+55	41	51.6	56	Skalná Pleso	1783	—01	20	58.8	+49	11	20.0
67	Lvov, Lemberg								31	Sonneberg	640	—00	44	46.19	+50	22	41.4
513	Lyon	299	—00	19	08.52	+45	41	41.0	191	Stalinabad Tadjik							
711	McDonald Observatory	2081	+06	56	05.34	+30	40	17.7	105	Sternberg Observatory							
990	Madrid	655	+00	14	45.10	+40	24	30.0	50	Stockholm	55	—01	13	14	+59	16	18
14	Marseilles (post-1864)	75	—00	21	34.55	+43	18	16.3	25	Stuttgart	344	—00	36	47.39	+48	47	00.7
27	Milan	120	—00	36	45.89	+45	27	59.2	420	Sydney	44	—10	04	49.19	—35	51	41.1
998	Mill Hill, London	82	+00	00	57.77	+51	36	46.3	75	Tartu, USSR	67	—01	46	53.18	+58	22	47.2
104	Moscow	166	—02	30	16.95	+55	45	19.8	192	Tashkent	477	—04	37	10.47	+41	19	30.4
414	Mt. Stromlo	768	—09	56	01.35	—35	19	16.0	37	Teramo, Italy	398	—00	54	56	+42	39	27
672	Mt. Wilson	1742	+07	52	14.33	+34	12	59.5	388	Tokyo, Mitaka	59	—09	18	10.10	+35	40	21.4
532	Munich	529	—00	46	26.02	+48	08	45.5	777	Toronto	116	+05	17	35.60	+43	40	00.8
330	Nanking Purple Mt.	367	—07	55	17.02	+32	03	59.9	4	Toulouse	195	—00	05	51.00	+43	36	44.1
19	Neuchâtel	488	—00	27	49.79	+46	59	50.6	38	Trieste (post-1898)	67	—00	55	05.23	+45	38	35.5
20	Nice	376	—00	29	12.10	+43	43	17.0	692	Tucson	—	—07	22	52	+32	24	
801	Oak Ridge, Harvard								22	Turin (Pino Torinese)	618	—00	31	05.95	+45	02	16.3
86	Odessa	53	—02	03	01.98	+46	28	37.5	62	Turku, Finland	28	—01	28	55.03	+60	27	08.7
790	Ottawa, Dominion Observatory	87	+05	02	51.95	+45	23	38.1	12	Uccle	105	—00	17	25.97	+50	47	55.0
533	Padua	38	—00	47	29.15	+45	24	01.3	786	U.S. Naval Observatory	86	+05	08	15.78	+38	55	14.0
535	Palermo	72	—00	53	25.87	+38	06	43.6	15	Utrecht	14	—00	20	31.01	+52	05	09.6
675	Palomar	1706	+07	47	27.36	+33	21	22.4	36	Vatican	450	—00	50	36.33	+41	44	47.4
7	Paris	67	—00	09	20.91	+48	50	11.0		Vienna (pre-1879)	186	—01	05	31.61	+48	12	35.5
538	Pola	32	—00	55	23.07	+44	51	48.6	45	Vienna (post-1879)	240	—01	05	21.35	+48	13	55.1
47	Poznan, Poland	85	—01	07	30.78	+52	23	54.3	558	Warsaw	121	—01	24	07.26	+52	13	04.6
79	Pretoria	1542	—01	52	54.9	—25	47	18	786(1)	Washington National Observatory	31	+05	08	12.15	+38	53	38.7
84	Pulkovo	75	—02	01	18.57	+59	46	18.5	23	Wiesbaden							
34	Rome, Monte Mario	152	—00	49	48.55	+41	55	19.2	754	Williams Bay Yerkes	334	+05	54	13.24	+42	34	12.6
	Rome	51	—00	49	55.12	+41	53	53.6	70	Wilno	122	—01	41	08.76	+54	40	59.1
110	Rostov								28	Würzburg	200	—00	39	44.71	+49	47	27.6
795	Rutherford, N. J.								797	Yale, New Haven	40	+54	51	40.58	+41	19	22.3
									77	Yale Southern Station (Johannesburg)	1741	—01	52	07.0	—26	11	14.0

Dr. Paul Herget of the Cincinnati Observatory is responsible for the codes (numbers) that are used to designate the various observatories. These code numbers will allow the interchange of data with other organizations adhering to the IAU.

This list is not complete; the number code is missing in some instances; and the altitude, longitude, and latitude are missing in others. Since these observatories are not used at present, the missing quantities will be added in a later revision of this report.

D. Instrument—Column 25

This column is used to designate the instrument used. In many cases, there have been two locations of the same observatory. This column will be used to provide the designation of the separate locations.

At present, only two codes are used. The data from the Six-Inch Transit Circle and the Nine-Inch Transit Circle of the U.S. Naval Observatory (USNO) have been given the instrument codes of 6 and 9, respectively.

E. Catalogue Code—Columns 26 Through 28

The codes presented in Table 2 will designate the catalogues used for obtaining the star positions to which observations were referred.

There are two series of codes: (1) numbers 1 through 105 indicate work performed at the USNO, and (2) numbers 901 through 974 are formed by prefixing the Smithsonian Astrophysical Observatory Catalog tape codes with a 900. The numbers 990 through 994 were added by T.C. Van Flandern.

F. Observation Parameters—Columns 29 Through 33 and 50

The following type of observation is listed in column 29:

Code	Observation
1	transit
2	micrometer
3	photographic

Table 2. Catalogue abbreviation and information

Code	Abbreviation	Location	Date	Observation	Code	Abbreviation	Location	Date	Observation
1	Abb ₁	Abbadia	1900	Cat. of 14263 stars	18	BD	Bonn	1855	Bonn Durchmusterung
2	Abb ₂	Abbadia	1900	Cat. of 13532 stars	19	AG Berl A 75	Berlin	1875	+20° to +15°
3	Alg	Algiers	1900	Cat. of 9997 stars	20	AG Berl B 75	Berlin	1875	+25° to +20°
4	AG Wash 00	Washington	1900	—14° to —18°	21	BX			
5	AG Wash 00	Washington	1900	—14° to —18°	22	2. Bord	Bordeaux	1900	+10° to +18°
6	AG	Berlin			23	CC Bord			
7	AG W-Ott 00	Wien-Ottakring	1900	—6° to —10°	24	Cbr E	Cambridge (England)	1875	+25° to +30°
8	AG Leip II 75	Leipzig	1875	+10° to +5°	25	Cbr M	Cambridge (Mass.)	1875	+50° to +55°
9	AG Alb 75	Albany	1875	+5° to +1°	26	Cod S	Cordoba	1893	Zodiacal Catalogue and General Catalogue
10	AG Strass 00	Strassburg	1900	—2° to —6°					
11	AG Nik 75	Nikolajev	1875	+1° to —2°	27	C.A.G.			
12	Bo gem	Bonn	1866	Ast. Nach. No. 1540	28	Ya	Washington	1860	Third edition
13	AOe 1842	Wien	1919	+45° to +80°	29	12y ₄₅	Greenwich	1845	12-year catalogue
14	LI				30	7y	Greenwich	1860	7-year catalogue
15	AW 1850	Wien	1890	+15° to +31°	31	N7y	Greenwich	1864	New 7-year catalogue
16	Kon 15	Königsberg	1815	Bessel zone					
17	B.A.C.	British Association Catalogue							

Table 2 (contd)

Code	Abbreviation	Location	Date	Observation	Code	Abbreviation	Location	Date	Observation
32	9y	Greenwich	1872	9-year catalogue	69	San ₁	Padova	1840	0° to +10°
33	H.C.				70	Sievers			
34	Hyderabad				71				
35	Kli 1860	Göttingen	1891	two volumes	72	Wien Meridian		1860-65	
36					73	Pulk 65	Pulkova	1865	Vols. XII, XIV
37	Dr. Forster	Berlin Observatory			74	WB			Weisse, B
38	Lalander	Berlin Observatory			75	Rbg	Pulkova	1875	Romberg Meridian
39	Lam	Munich	1850	2112 small stars	76	Lei Mer Obs		1865	
40	Grb	Groombridge	1810		77	Lorak			
41	Lpz II	Leipzig	1875	+5° to +10°	78	W Pal	Wien	1875	3458 stars
42	Kri	Kristiana	1900	+65° to +70°	79	Berl	Berlin	1865	2338 stars
43	MaP	Madras	1875	New General Catalogue	80	CB	Göttingen	1875	-0° to -1°
44	Mu ₁	Munich	1880		81	Rob	Armagh	1840	5345 stars
45	New Standard Zodiacal	Washington	1850	Clock and zodiacal	82	Berl A	Berlin	1875	Meridian
46	W-Ott 90	Wien-Ottakring	1890	1238 stars	83	Lamont (3)			
47	Oxf. Plot				84	San ₅	Trettenero	1860	0° to +3°
48	Par ₁	Paris	1845		85	Bo VI	Bonn	1855	
49	Sj	Schjellerup	1865	-15° to +15°	86	Kgb		1881	Meridian observation
50	Strb ₂ I	Strassburg	1885	2 volumes	87	Cp	Cape	1840-90	
51	SF ₉₂	San Fernando	1892		88		Meridian Obs. Bonn; Scheivar		
52	Fundamental Stars		1866	Dr. Gould	89	Gl	Glasgow	1870	Grant's list
53	Toul B o ^h ... 1 ^h ...	Toulouse	1900	photographic	90	M ₁	Hamburg	1844	
54	W	Weisse	1825	-15° to +15°	91	Port			
55	W ₂	Weisse	1825	+15° to +45°	92	Pu M	Pulkova	1855	Meridian
56	Wash Cat.	Washington	1882	73, 78	93	A.We.			
57	Hedr	Washington	1900	zodiacal stars	94	Par ₂	Paris	1860	
58	Yale	New Haven	1950	21 volumes	95	RC ₃	Cambridge	1875	Third Radcliff
59					96				
60	Weisse Lan XI				97	Karlsruhe			
61	Gr.			observed by Johnson	98	Ru ₂			
62	R		1840	Catalogue of Reslhuber	99	Par ₃	Paris	1875	
63	Challis				100	Hels	Helsingfors	1875	+55° to +65°
64	Do ₉₀ M	Dorpat	1850	Bonn Durchmusterung XVI	101				
65	Nautical Alma.		1858	Pisce	102	Abb ₃	Abbadia	1900	7443 stars
66	Ru H	Hamburg	1845		103	Lic Schl			
67	Lal	London	1800	F. Baily	104	C.C. Alg			
68	KZA	Königsberg	1825	1309 stars	105	Dr. Winnecki Meridian Observations		1863	

Table 2 (contd)

Code	Abbreviation	Location	Date	Observation	Code	Abbreviation	Location	Date	Observation
901	AG	AGK 2 1	1950	85° to 80°	934	24	Yale 24	1950	30° to 25°
901	AG	AGK 2 1	1950	80° to 75°	935	25	Yale 25	1950	25° to 20°
901	AG	AGK 2 1	1950	75° to 70°	936	26A	Yale 26 I	1950	89° to 85°
902	AG	AGK 2 2	1950	70° to 65°	937	26B	Yale 26 II	1950	55° to 50°
902	AG	AGK 2 2	1950	65° to 60°	938	27	Yale 27	1950	60° to 55°
903	AG	AGK 2 5	1950	50° to 45°	940	C7	Cape 17	1950	30° to 35°
904	AG	AGK 2 6	1950	45° to 40°	941	C8	Cape 18	1950	35° to 40°
905	AG	AGK 2 7	1950	40° to 35°	942	C9	Cape 19	1950	52° to 56°
906	AG	AGK 2 8	1950	35° to 30°	943	C0	Cape 20	1950	56° to 64°
920	11	Yale 11	1950	10° to 14°	948	CZ	Cape Zone	1900	40° to 52°
921	12A	Yale 12 I	1950	14° to 18°	960	M3	Me 3	1890	64°
922	12B	Yale 12 II	1950	18° to 20°	961	M4	Me 4	1900	-89°
923	13A	Yale 13 I	1950	20° to 22°	970	GC	GC	1950	-89°
924	13B	Yale 13 II	1950	27° to 30°	971	F3	FK 3	1950	
925	14	Yale 14	1950	22° to 27°	974	F4	FK 4	1950	+89°
926	16	Yale 16	1950	6° to 10°	990		ZC (Robertson)		
927	17	Yale 17	1950	-2° to -6°	991		FK 4 (Dynamical)		
928	18	Yale 18	1950	20° to 15°	992		FK 4S (Supplement)		
929	19	Yale 19	1950	15° to 10°	993		N30		
930	20	Yale 20	1950	5° to 1°	994		AGK3R		
931	21	Yale 21	1950	+1° to -2°					
932	22A	Yale 22 I	1950	9° to 5°					
933	22B	Yale 22 II	1950	10° to 9°					

It should be noted that these codes are coordinated with the codes on the radar data card. The numbers 4 and 5 are reserved for use on the radar cards.

Column 30 lists observers from 1866 through 1967. The codes in Table 3 are used to designate the observers for observations made with the Six-Inch Transit Circle and Nine-Inch Transit Circle from 1866 through 1967. It should be noted that the 1967 codes became alphabetical, in agreement with codes already used in USNO cards.

Column 31 is used for clamp designation. Table 4 lists the volumes and source code.³ A compilation of the various codes, which have been used to refer to the positions of the clamp, has been made.

For source code 7, the meaning is not ambiguous as to position of the clamp. For source code 8, the introduction to the volume was not available and, therefore, the mean-

ing of the designation was assumed, based upon similar designations.

In source codes 9 and 0, the designations 1 and 2 are equivalent to:

1 = West

2 = East

For these sources, the General Planetary Format (GPF) code is the same:

1 = West

2 = East

Source code 6 has a different designation. It means that the clamp is east (E) or west (W) and the additional I or II refers to the position of the instrument.

The decision to give GPF codes of 3 through 6 to these designations is arbitrary. It allows the peculiarity of this set of observations to be noted.

³Informal set of explanatory notes by Dr. C. Oesterwinter, NWL, Sept. 15, 1967.

Table 3. Transit circle observers

Source code	Observer	Observed	Instru- ment	Observa- tory	GPF ^a code	Source code	Observer	Observed	Instru- ment	Observa- tory	GPF ^a code
N	S. Newcomb	1866-1891		USNO	0	HD	J. C. Hammond	1925-1933	6 in.	USNO	0
H	A. Hall	1866-1867		USNO	1	WS	C. B. Watts	1925-1941	6 in.	USNO	1
HA	W. Harkness	1866-1891		USNO	2	MY	W. C. Myers	1925-1926	6 in.	USNO	2
E	J. R. Eastman	1866-1891		USNO	3	WI	J. D. Wise	1925-1927	6 in.	USNO	3
HN	E. S. Holden	1866-1891		USNO	4	WL	J. E. Willis	1926-1933	6 in.	USNO	4
F	E. Frisby	1866-1891		USNO	5	WH	G. C. Whittaker	1928-1941	6 in.	USNO	5
R	J. A. Rogers	1866-1867		USNO	6	LY	U. S. Lyons	1928-1932	6 in.	USNO	6
T	C. Thirion	1866-1891		USNO	7	HF	A. H. Hadfield	1928-1929	6 in.	USNO	7
A	C. Abbe	1866-1891		USNO	8	SS	B. P. Sharpless	1929-1941	6 in.	USNO	8
S	O. Stone	1870-1875		USNO	9	AD	A. N. Adams	1931-1941	6 in.	USNO	9
SK	A. N. Skinner	1873-1875		USNO	A	SW	N. C. Seewald	1936-1940	6 in.	USNO	A
S	A. N. Skinner	1876-1891		USNO	A	MI	A. H. Mikesell	1936-1937	6 in.	USNO	B
P	H. M. Paul	1866-1891		USNO	B						
PR	H. S. Pritchett	1866-1891		USNO	C	K	J. W. Kitchens	1946-1948	6 in.	USNO	0
R	M. Rock	1880-1883		USNO	D	SK	R. E. Strickler	1948-1948	6 in.	USNO	1
W	W. C. Winlock	1866-1891		USNO	E	DU	R. L. Duncombe	1942-1945	6 in.	USNO	2
H	A. Hall, Jr.	1889-1891		USNO	F	BL	S. M. Bestul	1942-1948	6 in.	USNO	3
						AD	A. N. Adams	1941-1948	6 in.	USNO	4
B	E. A. Boeger	1901-	6 in.	USNO	0	SC	F. P. Scott	1945-1947	6 in.	USNO	5
BR	W. M. Brown	1901-	6 in.	USNO	1	ST	J. Steinheider	1944-1948	6 in.	USNO	6
EI	W. S. Eichelberger	1901-	6 in.	USNO	2	MI	A. H. Mikesell	1945-1947	6 in.	USNO	7
HD	J. C. Hammond	1901-1903	6 in.	USNO	3	WS	C. B. Watts	1941-1948	6 in.	USNO	8
HH	W. S. Harshman	1901-	6 in.	USNO	4	WH	G. C. Whittaker	1941-1942	6 in.	USNO	9
K	T. I. King	1901-	6 in.	USNO	5	SS	B. P. Sharpless	1941-1941	6 in.	USNO	A
LA	G. K. Lawton	1901-	6 in.	USNO	6	GO	D. S. Goalwin	1941-1942	6 in.	USNO	B
L	F. B. Littell	1901-1903	6 in.	USNO	7						
R	H. L. Rice	1901-	6 in.	USNO	8	0	J. K. Gleim	1951-1955	6 in.	USNO	0
S	A. N. Skinner	1901-	6 in.	USNO	9	1	J. W. Kitchens	1949-1955	6 in.	USNO	1
U	M. Updegraff	1901-1903	6 in.	USNO	A	2	R. E. Strickler	1949-1950	6 in.	USNO	2
Y	E. I. Yowell	1901-	6 in.	USNO	B	3	S. M. Bestul	1950-1955	6 in.	USNO	3
						4	A. D. Allen	1949-1955	6 in.	USNO	4
U	M. Updegraff	1909-1910	6 in.	USNO	0	5	A. N. Adams	1949-1955	6 in.	USNO	5
L	F. B. Littell	1910-1911	6 in.	USNO	1	6	F. P. Scott	1949-1949	6 in.	USNO	6
HD	J. C. Hammond	1911-1918	6 in.	USNO	2	7	J. L. Schombert	1950-1955	6 in.	USNO	7
FN	M. Frederickson	1909-1918	6 in.	USNO	3	8	N. E. Hanson	1949-1949	6 in.	USNO	8
T	E. D. Tillyer	1909-1911	6 in.	USNO	4	8	R. W. Rhynsbarger	1952-1955	6 in.	USNO	9
PK	R. M. Packard	1909-1909	6 in.	USNO	5	9	C. B. Watts	1949-1951	6 in.	USNO	A
R	D. Rines	1911-1914	6 in.	USNO	6						
WY	C. D. Wylie	1913-1918	6 in.	USNO	7	0	J. K. Gleim	1956-	6 in.	USNO	0
AN	R. Aston	1914-1915	6 in.	USNO	8	1	J. W. Kitchens	1956-	6 in.	USNO	1
M	H. R. Morgan	1913-1926	9 in.	USNO	0	2	W. T. Toland	1956-	6 in.	USNO	2
P	J. Pawling	1913-1926	9 in.	USNO	1	3	S. M. Bestul	1956-	6 in.	USNO	3
EP	J. B. Eppes	1913-1914	9 in.	USNO	2	4	A. D. Allen	1956-	6 in.	USNO	4
S	L. P. Steele	1914-1917	9 in.	USNO	3	5	A. N. Adams	1956-	6 in.	USNO	5
SR	P. Sollenberger	1914-1919	9 in.	USNO	4	6	D. K. Scott	1956-	6 in.	USNO	6
BN	H. E. Burton	1919-1925	9 in.	USNO	5	7	M. S. Kalish	1956-	6 in.	USNO	7
RY	G. M. Raynsford	1919-1926	9 in.	USNO	6	8	R. W. Rhynsbarger	1956-	6 in.	USNO	8

^aGPF = General Planetary Format.

Table 3 (contd)

Source code	Observer	Observed	Instrument	Observatory	GPF ^a code	Source code	Observer	Observed	Instrument	Observatory	GPF ^a code
9	G. E. Pease	1956-	6 in.	USNO	9	1	F. S. Gauss	1965-	6 in.	USNO	1
	F. E. Followill	1961-	6 in.	USNO	A	2	W. T. Toland	1965-	6 in.	USNO	2
	F. S. Gauss	1962-	6 in.	USNO	B	3	F. J. Giovane	1965-	6 in.	USNO	3
	B. L. Klock	1960-	6 in.	USNO	C	4	B. L. Klock	1965-	6 in.	USNO	4
1	F. S. Gauss	1963-	6 in.	USNO	1	5	A. N. Adams	1965-	6 in.	USNO	5
2	W. T. Toland	1963-	6 in.	USNO	2	6	D. K. Scott	1965-	6 in.	USNO	6
3	S. M. Bestul	1963-	6 in.	USNO	3	7	H. E. Durgin	1965-	6 in.	USNO	7
4	B. L. Klock	1963-	6 in.	USNO	4	8	R. W. Rhynsbarger	1965-	6 in.	USNO	8
5	A. N. Adams	1963-	6 in.	USNO	5	9	J. R. Sievers	1965-	6 in.	USNO	9
6	D. K. Scott	1963-	6 in.	USNO	6	A	A. N. Adams	1966-1967	6 in.	USNO	A
7	M. S. Kalish	1963-	6 in.	USNO	7	C	H. E. Crull	1966-1967	6 in.	USNO	C
8	R. W. Rhynsbarger	1963-	6 in.	USNO	8	D	H. E. Durgin	1966-1967	6 in.	USNO	D
9	G. E. Pease	1963-	6 in.	USNO	9	G	F. S. Gauss	1966-1967	6 in.	USNO	G
1	F. S. Gauss	1964-	6 in.	USNO	1	H	P. D. Hemenway	1966-1967	6 in.	USNO	H
2	W. T. Toland	1964-	6 in.	USNO	2	I	J. R. Sievers	1966-1967	6 in.	USNO	I
3	S. M. Bestul	1964-	6 in.	USNO	3	J	E. S. Jackson	1966-1967	6 in.	USNO	J
4	B. L. Klock	1964-	6 in.	USNO	4	K	B. L. Klock	1966-1967	6 in.	USNO	K
5	A. N. Adams	1964-	6 in.	USNO	5	L	R. E. Laubscher	1966-1967	6 in.	USNO	L
6	D. K. Scott	1964-	6 in.	USNO	6	R	R. W. Rhynsbarger	1966-1967	6 in.	USNO	R
7	R. W. Milkey	1964-	6 in.	USNO	7	S	C. A. Smith, Jr.	1966-1967	6 in.	USNO	S
8	R. W. Rhynsbarger	1964-	6 in.	USNO	8	T	W. A. Toland	1966-1967	6 in.	USNO	T
9	G. E. Pease	1964-	6 in.	USNO	9	W	H. S. Liszt	1966-1967	6 in.	USNO	W
0	P. D. Hemenway	1965-	6 in.	USNO	0	X	M. A. Seeds	1966-1967	6 in.	USNO	X
						Y	T. E. Corbin	1966-1967	6 in.	USNO	Y
						Z	F. J. Giovane	1966-1967	6 in.	USNO	Z

Table 4. Clamp designation for Six-Inch Transit Circle

Volume	Source code	Designation	GPF code
XI	6	EI, EII, WI, WII	EI = 3, EII = 4, WI = 5, WII = 6
XIII	7	E, W ^a	E = 2, W = 1
XV, Part V	8	1, 2	1, 2
XVI, Part I	9	1, 2	1, 2
XVI, Part III	0	1, 2	1, 2
^a E = East W = West			

Circle designations are presented in column 32; RALIMB designations in column 33; DELIMB in column 50 (see Table 5). Observations of the sun, Mercury, and Venus for the years 1911 through 1918 are found in source code 6. The current method of circle and limb designations was not used. The codes WI, WII, EI and EII are listed under instruments. This code has been translated into GPF code for clamp designation. In the case of RALIMB and DELIMB, the codes I, II, and * are

Table 5. Limb codes for meridian observatories

Volume	Source code	Circle	RALIMB	DELIMB
XI	6 see below 6 = Venus		I, II,*	N, S
XIII	7 = Mercury, Jupiter 7 = Saturn, Uranus, Neptune	None	I, II, C	N, S, C
XV, Part V	8 = sun 8 = planets	1 to 5 1 to 5	— 1, 2, 3	— 1, 2, 3
XVI, Part I	9	1 to 10	1, 2, 3	1, 2, 3
XVI, Part III	0	1 to 3	1, 2, 3	1, 2, 3
XIX, Part I	1	1 to 3	1, 2, 3	1, 2, 3
Circulars 103, 105, 108, 115, 118			1, 2, C	N, S, C

used for Venus. The code I is designated for the preceding limb; II is designated for the following limb; and * means center of the portion of illuminated disk, adjacent to the bright limb, observed in right ascension.

The GPF codes are as follows:

Code	Designation
1	Clamp west; preceding limb; north limb
2	Clamp east; following limb; south limb
3	Center (of the disk of a planet)

These codes are equivalent to the same numbering system used throughout the publications of the USNO. Additional designations are equivalent as follows:

Code	GPF Code
I N (N)orth limb	1
II S (S)outh limb	2
C C (C)enter	3

If the number (1-2) or (I-II) is used together in a limb code, the GPF code is 4.

For the codes designating the circle, the numbers are identical for both the USNO and GPF codes except for source code 9 (Ref. 1), where the circle position 10 will be designated as A.

G. Right Ascension—Columns 34 Through 42

The right ascension is recorded in hours, minutes, and seconds. Two columns for hours and two columns for minutes are provided along with five columns for seconds and decimals of a second. The decimal point is implied between the second and third columns.

The values placed on the card are exactly as found in the respective publications listed in Refs. 1 through 10.

H. Equinox—Columns 43 and 60

The following information is listed in columns 43 and 60:

- 0 = true equator and equinox of date
- 1 = mean equator and equinox of beginning of year
- 2 = mean equator and equinox of beginning of next year
- 3 = mean equator and equinox of 1950.0
- 4 = mean equator and equinox of 1925.0
- 5 = mean equator and equinox of 1900.0
- 6 = mean equator and equinox of 1875.0
- 7 = mean equator and equinox of 1850.0
- 8 = mean equator and equinox of 1800.0
- 9 = mean equator and equinox of 1750.0

Codes A through Z will designate additional equinoxes, as necessary.

I. Right Ascension (Comparison)—Columns 44 Through 49

This field is used to record the observed minus computed ($O - C$) data which is given along with the observation. It is based upon the comparison ephemeris used by the publisher of the data.

The decimal point is implied between columns 46 and 47.

J. Declination—Columns 51 Through 59

The declination is recorded in degrees, minutes, and seconds of arc. Three columns are provided for a sign plus two significant figures of degrees. Two columns are provided for minutes and four columns for seconds. The decimal point is implied between the second and third column of the seconds.

K. Declination (Comparison)—Columns 61 Through 65

This field contains the declination comparison. A sign is placed in column 61, and the decimal point is implied between columns 63 and 64. The notes on the right ascension comparison also hold for this field.

L. Year—Columns 73 Through 76

The calendar year of the observation is recorded here for quick reference.

M. Source Number—Columns 77 Through 80

A source number provided by the agency punching the cards is recorded. This allows the origin of the data cards to be traced. The convention adopted is to precede the source number with a D for Dahlgren (NWL)-punched cards, a J for JPL, and U for USNO.

III. Radar Card

The radar data card is shown in the Appendix (Fig. A-2).

A. Planet Number—Columns 1 Through 4

The codes for the radar card are identical to those used in the optical card.

B. Julian Date—Columns 5 Through 21

The time tags associated with a radar observation must be given to the full accuracy. The Julian date must have at least 8 decimal digits.

C. Observatory Codes—Columns 22 Through 24 and 26 Through 28

The radar card observatory codes are listed in Table 6. These two fields on the card contain a code identifying the site where the data were taken. The first field is used when a single antenna both transmits the signal and receives the echo. The second field is necessary when two sites are used to obtain the range point. The first field contains the code which refers to the transmitter and the second contains the code which refers to the receiver location.

Column 25, which is located between the two fields, has two codes which differentiate between mono-static and bi-static ranging:

Code	Ranging
1	mono-static (the transmitter and receiver were coincident)
2	bi-static (the transmitter and receiver were located at separate sites)

D. Type of Observation—Column 29

The following codes apply to the type of observation:

Code	Observation
4	Radar (AT)
5	Radar (UT)

E. Range—Columns 30 Through 42

The two-way range delay to the respective planets is recorded in microseconds. A decimal point is implied between columns 41 and 42.

Table 6. Radar transmitter and receiver codes

Code	Location	Name	Instrument	Radius, km	Geodetic latitude, deg	Geocentric ^a latitude, deg	East longitude, deg
010	Arecibo, Puerto Rico	Cornell University Arecibo Ionospheric Observatory	Antenna ^b	6376.5602	18.343 389	18.228 761	293.246 972
020	Goldstone, Calif.	California Institute of Technology (JPL) 1961 data ^c	Transmitter radius	6372.0362		35.119 983	243.195 194
021		1961 data ^c	Receiver radius	6372.0355		35.206 019	243.151 750
022		California Institute of Technology (JPL) Venus Site—DSS 13 ^d	Antenna	6372.1770	35.247 7189	35.066 5981	243.205 9925
023	Tyngsboro, Mass. ^e	210-ft Mars Site—DSS 14 ^d	Antenna	6372.0527	35.425 9278	35.244 4061	243.111 3473
030		Lincoln Laboratories—Massachusetts Institute of Technology Haystack site	Antenna	6368.5517	42.623 194	42.431 518	288.511 333
031		Lincoln Laboratories—Massachusetts Institute of Technology Millstone radar	Antenna	6368.5638	42.617 333	42.425 661	288.508 611
040	Crimea	Crimea Tracking Station, USSR	Antenna	6367.416	—	44.980 1139	+ 33.25

^aGeocentric coordinates computed using the following values: $\rho = 6378.165$ km, $1/f = 298.3$.
^bAntenna implies that this location was both a transmitter and a receiver.
^cMuhleman, D. O., Lawson, C. L., Holdridge, D. B., O'Handley, D. A., *JPL Radar Range and Doppler Observations of Venus, 1961–1966*, p. 4. Technical Report 32-1123, Jet Propulsion Laboratory, Pasadena, Calif.
^dJPL Coordinates for Goldstone: DSS 13 and DSS 14, Jay Curtright, May 1, 1968.
^eMassachusetts Institute of Technology, Lincoln Laboratory, Site Positions, Millstone, Haystack and Arecibo Radio Observatories, May 28, 1968.

This range measurement is recorded exactly as published. The units of time delay may therefore be recorded in Universal Time seconds (nonuniform) or Atomic Time seconds (uniform).

F. Standard Deviation (Range)—Columns 43 Through 47

The quoted standard deviation of the observation is recorded in microseconds. The decimal point is implied between columns 46 and 47.

G. Observations—Column 48

The following coded information is listed in column 48:

Code	Observations
1	Range
2	Doppler
3	Range and Doppler
4	Range difference

This code is used to differentiate the types of radar observation recorded on the radar card.

H. Doppler—Columns 49 Through 57

This field is distinct from the range field because it is possible to have both range and Doppler measurements for the same epoch. The unit of measurement used is hertz. The decimal point is implied between columns 56 and 57.

I. Standard Deviation (Doppler)—Columns 58 Through 62

The standard deviation of the Doppler (in hertz), is taken from the publication or manuscript and recorded in this field. The decimal point is implied between columns 60 and 61.

J. Frequency Offset—Columns 63 Through 66

This field contains the frequency offset from the basic atomic frequency of cesium 133. The frequency offset is made to maintain the Atomic Time scale as close as possible to the Universal Time scale, which is based upon the rotation of the earth. Although the offsets are internationally agreed upon and take effect at 0^h, the beginning of the new year, the various radar sites may elect to maintain a given frequency for a period of time beyond the official date.

In some cases the frequency offset may not even be that which was internationally agreed upon. This correction must be made to a range value so as to make the units of time uniform (AT).

K. Frequency—Columns 67 Through 72

The frequency of the transmitter is recorded in megahertz. The data are right-justified in the field.

L. Year—Columns 73 Through 76

The calendar year of observation is recorded herein for quick reference.

M. Source Number—Columns 77 Through 80

The basis for the data in this field is the same as for the optical card. The list of source codes for JPL-punched radar observations is presented in Table 7.

Table 7. Source codes for JPL-punched radar observations

Code	Source
J001	Pettengill, G. H., Dyce, R. B., and Campbell, D. B., "Radar Measurements at 70 cm of Venus and Mercury," <i>Astron. J.</i> , Vol. 72, No. 3, 1967
J002	Private communication, Gold, T., and Crawford, D., Cornell University, Sept. 20, 1967.
J003	Lawson, C. L., and Holdridge, D. B., <i>Compression of JPL Venus Radar Data</i> , Technical Memorandum 155, Section 314, Computation and Analysis Section, Jet Propulsion Laboratory, Pasadena, Calif., Feb. 3, 1967
J004	Evans, et al., "Radio Echo Observations of Venus and Mercury at 23 cm Wavelengths," <i>Astron. J.</i> , Vol. 70, No. 7, 1965
J005	Dyce, R. B., and Pettengill, G. H., "Radar Observations of Mars and Jupiter at 70 cm," <i>Astron. J.</i> , Vol. 72, No. 6, 1967
J006	Evans, et al., "Radar Observations of Venus at 23 cm in 1965/1966," <i>Astron. J.</i> , Vol. 71, No. 9, 1966
J007	Private communication, Millstone, Smith, W., Lincoln Laboratory with Melbourne, W. G., JPL, Oct. 1967.
J008	Private communication, Haystack, Smith, W., Lincoln Laboratory with Melbourne, W. G., JPL, Oct. 1967.
J009	O'Handley, D. A., <i>Reconstructed Data Preliminary</i> , Technical Manual 311-39, Jet Propulsion Laboratory, Pasadena, Calif.
J010	Mars—Private communication, W. B. Smith/listing of Shapiro
J011	Mercury—Private communication, R. Goldstein, March 11, 1968
J012	Venus—Old observations

IV. Modified Card Format

The modified card format shown in the Appendix (Fig. A-3) is identical to the format of the optical card with the following exceptions.

A. Modified Card Format—Columns 44 Through 49 and 61 Through 65

These columns contain the $(O - C)$ residuals of the observations compared with Mercury ephemeris used at the USNO. The first field is right ascension and the second is declination.

B. Modified Card Format—Columns 66 Through 67 and 68 Through 69

The weights for right ascension and declination, as assigned by Prof. G. M. Clemence, are found in these fields, respectively. If the weights were fractional, asterisks are stored in the columns.

At present, the source numbers (columns 77 through 80) of these Mercury observations are assigned the code U001.

References

1. *Publications of the U.S. Naval Observatory, Washington, D.C.*, Second Series, Vol. XVI, Part I, pp. 59–203, U.S. Naval Observatory, Washington, D.C., 1949.
2. *Publications of the U.S. Naval Observatory, Washington, D.C.*, Second Series, Vol. XI, pp. 153–179, U.S. Naval Observatory, Washington, D.C., 1927.
3. *Publications of the U.S. Naval Observatory, Washington, D.C.*, Second Series, Vol. XIII, Part II, pp. 101–155, U.S. Naval Observatory, Washington, D.C., 1933.
4. *Publications of the U.S. Naval Observatory, Washington, D.C.*, Second Series, Vol. XVI, Part III, pp. 395–445, U.S. Naval Observatory, Washington, D.C., 1952.
5. *Publications of the U.S. Naval Observatory, Washington, D.C.*, Second Series, Vol. XIX, Part I, pp. 47–110, U.S. Naval Observatory, Washington, D.C., 1964.
6. *Observations of the Sun, Moon, and Planets; Six-Inch Transit Circle Results, 1956–1962*, Circular No. 103, U.S. Naval Observatory, Washington, D.C., Oct. 9, 1964.
7. *Observations of the Sun, Moon, and Planets; Six-Inch Transit Circle Results, March 8, 1963–July 2, 1964*, Circular No. 105, U.S. Naval Observatory, Washington, D.C., Nov. 27, 1964.
8. *Observations of the Sun, Moon, and Planets; Six-Inch Transit Circle Results, July 7, 1964–Dec. 24, 1964*, Circular No. 108, U.S. Naval Observatory, Washington, D.C., July 1, 1965.
9. *Observations of the Sun, Moon, and Planets; Six-Inch Transit Circle Results, Jan. 11, 1965–April 11, 1966*, Circular No. 115, U.S. Naval Observatory, Washington, D.C., Feb. 1, 1967.
10. *Observations of the Sun, Moon, and Planets; Six-Inch Transit Circle Results, May 29, 1966–July 10, 1967*, Circular No. 118, U.S. Naval Observatory, Washington, D.C., Jan. 5, 1967.

Appendix Card Bibles

COL.	DESCRIPTION	REMARKS
		PLANET NUMBER
10		JULIAN DATE (UT)
20		OBSERVATORY CODE
		INSTRUMENT
30		CATALOGUE CODE
		TYPE OF OBSERVATION
		OBSERVER
		CLAMP
		CIRCLE
		RALIMB
40		RIGHT ASCENSION
		EQUINOX CODE
50		RIGHT ASCENSION (COMPARISON)
		DELIMB
60		DECLINATION
		EQUINOX CODE
		DECLINATION (COMPARISON)
70		YEAR
		SOURCE NUMBER
80		

Fig. A-1. Optical card—revision 2

COL.	DESCRIPTION	REMARKS
1		PLANET NUMBER
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		JULIAN DATE (UT)
21		TRANSMITTER AND/OR RECEIVER CODE
22		CODE 1
23		RECEIVER
24		TYPE OF OBSERVATION
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		RANGE (MICROSECONDS)
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		STANDARD DEVIATION RANGE
51		OBSERVATIONS ON CARD
52		
53		
54		
55		
56		
57		
58		
59		
60		DOPPLER
61		
62		
63		
64		
65		
66		
67		
68		
69		
70		STANDARD DEVIATION DOPPLER
71		
72		
73		
74		
75		
76		
77		
78		
79		
80		FREQUENCY OFFSET (RANGE - UT TO A1)
81		
82		
83		
84		
85		
86		
87		
88		
89		
90		
91		
92		
93		
94		
95		
96		
97		
98		
99		
100		
101		
102		
103		
104		
105		
106		
107		
108		
109		
110		
111		
112		
113		
114		
115		
116		
117		
118		
119		
120		
121		
122		
123		
124		
125		
126		
127		
128		
129		
130		
131		
132		
133		
134		
135		
136		
137		
138		
139		
140		
141		
142		
143		
144		
145		
146		
147		
148		
149		
150		
151		
152		
153		
154		
155		
156		
157		
158		
159		
160		
161		
162		
163		
164		
165		
166		
167		
168		
169		
170		
171		
172		
173		
174		
175		
176		
177		
178		
179		
180		
181		
182		
183		
184		
185		
186		
187		
188		
189		
190		
191		
192		
193		
194		
195		
196		
197		
198		
199		
200		
201		
202		
203		
204		
205		
206		
207		
208		
209		
210		
211		
212		
213		
214		
215		
216		
217		
218		
219		
220		
221		
222		
223		
224		
225		
226		
227		
228		
229		
230		
231		
232		
233		
234		
235		
236		
237		
238		
239		
240		
241		
242		
243		
244		
245		
246		
247		
248		
249		
250		
251		
252		
253		
254		
255		
256		
257		
258		
259		
260		
261		
262		
263		
264		
265		
266		
267		
268		
269		
270		
271		
272		
273		
274		
275		
276		
277		
278		
279		
280		
281		
282		
283		
284		
285		
286		
287		
288		
289		
290		
291		
292		
293		
294		
295		
296		
297		
298		
299		
300		
301		
302		
303		
304		
305		
306		
307		
308		
309		
310		
311		
312		
313		
314		
315		
316		
317		
318		
319		
320		
321		
322		
323		
324		
325		
326		
327		
328		
329		
330		
331		
332		
333		
334		
335		
336		
337		
338		
339		
340		
341		
342		
343		
344		
345		
346		
347		
348		
349		
350		
351		
352		
353		
354		
355		
356		
357		
358		
359		
360		
361		
362		
363		
364		
365		
366		
367		
368		
369		
370		
371		
372		
373		
374		
375		
376		
377		
378		
379		
380		
381		
382		
383		
384		
385		
386		
387		
388		
389		
390		
391		
392		
393		
394		
395		
396		
397		
398		
399		
400		
401		
402		
403		
404		
405		
406		
407		
408		
409		
410		
411		
412		
413		
414		
415		
416		
417		
418		
419		
420		
421		
422		
423		
424		
425		
426		
427		
428		
429		
430		
431		
432		
433		
434		
435		
436		
437		
438		
439		
440		
441		
442		
443		
444		
445		
446		
447		
448		
449		
450		
451		
452		
453		
454		
455		
456		
457		
458		
459		
460		
461		
462		
463		
464		
465		
466		
467		
468		
469		
470		
471		
472		
473		
474		
475		

COL .	DESCRIPTION	REMARKS
10		THE FIELDS BETWEEN THE DOTTED LINES CONTAIN THE QUANTITIES WHICH DIFFER FROM THE STANDARD FORMAT
20		
30		
40		
50		RIGHT ASCENSION (O-C)
60		DECLINATION (O-C)
70		WEIGHT R.A.
80		WEIGHT DEC
		THE WEIGHTS ARE THOSE ASSIGNED BY CLEMENCE. IF THE WEIGHTS WERE FRACTIONAL ASTERISKS ARE STORED IN THE COLUMNS

Fig. A-3. Optical card for USNO Mercury optical observations—revision 2 (modified)