Technical Report 32-1296

# Card Format for Optical and Radar Planetary Data

Douglas A. O'Handley

JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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# 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
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Mr. Lloyd Carpenter, Goddard Space Flight Center
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## 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.

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## 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 Mercury[1]
P002 Venus
P004 Mars
P005 Jupiter
P006 Saturn
P007 Uranus
P008 Neptune
P009 Pluto
P010 Sun
P011 Moon

[1]P = 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]

[2]Information 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 h m s | Latitude ° ′ ″ |
|---|---|---|---|---|
| 119 | Abastumani | 1580 | −02 51 18.08 | +41 45 18.2 |
| 8 | Algiers | 345 | −00 12 08.53 | +36 48 04.8 |
| 210 | Alma Ata | 1450 | −05 07 49.76 | +43 11 16.9 |
| 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 |
| 57 | Belgrade (post-1931) | 253 | −01 22 03.20 | +44 48 13.2 |
| 660 | Berkeley | 94 | +08 09 02.91 | +37 52 23.5 |
| | Berlin (1835–1913) | 47 | −00 53 34.80 | +52 30 16.7 |
| 16 | Besancon | 312 | −00 23 57.42 | +47 14 59.8 |
| 74 | Bloemfontein | 1490 | −01 44 57 | −29 05 45 |
| 520 | Bonn | 62 | −00 28 23.18 | +50 43 45.0 |
| 999 | Bordeaux | 73 | +00 02 06.60 | +44 50 07 |
| 821 | Bosque Alegre, Argentina | 1250 | +04 18 11.20 | −31 35 53 |
| 73 | Bucharest | 83 | −01 44 23.20 | +44 24 49.4 |
| 53 | Budapest (pre-1933) | 474 | −01 15 54.00 | +47 29 58.0 |
| 802 | Cambridge, Harvard | 24 | +04 44 31.05 | +42 22 47.6 |
| 51 | Cape, South Africa | 10 | −01 13 54.38 | −33 56 02.5 |
| | Cerro El Roble, Chile (Maksutov) | 2000 | +04 44 38 | −32 59 00 |
| 765 | Cincinnati (post-1873) | 247 | +05 37 41.40 | +39 08 19.8 |
| 35 | Copenhagen | 14 | −00 50 18.69 | +55 41 12.6 |
| 822 | Cordoba | 434 | +04 16 47.16 | −31 25 16.4 |
| 55 | Cracow | 221 | −01 19 50.30 | +50 03 52.0 |
| 779 | David Dunlap Observatory | 244 | +05 17 41.3 | +43 51 46 |
| | Durham | 107 | +00 06 19.75 | +54 46 06.2 |
| 18 | Düsseldorf | 46 | −00 27 02.69 | +51 12 25.0 |
| 136 | Engelhardt, Kazan | 121 | −03 15 15.74 | +55 50 20.2 |
| 689 | Flagstaff, USNO | 2310 | +07 27 02.1 | +35 11 28.0 |
| 517 | Geneva (1901) | 407 | −00 24 36.61 | +46 11 59.3 |
| 760 | Goethe Link Observatory | 300 | +05 45 34.86 | +39 32 57.7 |
| 000 | Greenwich | 47 | 00 00 00.00 | +51 28 38.2 |
| 29 | Hamburg–Bergedorf | 41 | −00 40 57.74 | +53 28 46.9 |
| 24 | Heidelberg–Königstuhl | 567 | −00 34 53.13 | +49 23 55.2 |
| 218 | Hyderabad | 554 | −05 13 48.98 | +17 25 54.3 |
| 80 | Istanbul | 65 | −01 55 52 | +41 00 45 |
| | Jena | 165 | −00 46 20.22 | +50 55 34.9 |
| 76 | Johannesburg–Hartebeespoort | 1220 | −01 51 30.44 | −25 46 22.4 |
| 78 | Johannesburg | 1741 | −01 52 07.00 | −26 11 14.0 |
| 21 | Karlsruhe (1955) | 128 | −00 33 32.51 | +49 01 26.6 |
| 135 | Kazan City Observatory | 79 | −03 16 29.03 | +55 47 23.9 |
| 85 | Kiev | 184 | −02 02 00.56 | +50 27 11.8 |
| 186 | Kitab | 658 | −04 27 31.7 | +39 08 01.7 |
| 58 | Königsberg | 24 | −01 21 58.97 | +54 42 50.5 |
| 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 h m s | Latitude ° ′ ″ |
|---|---|---|---|---|
| 13 | Leiden | 6 | −00 17 56.15 | +52 09 19.8 |
| 81 | Leiden Station, Johannesburg | | | |
| 534 | Leipzig | 119 | −00 49 33.92 | +51 20 05.9 |
| 662 | Lick, Mt. Hamilton | 1283 | +08 06 34.93 | +37 20 25.3 |
| 690 | Lowell Observatory | 2210 | +07 26 44.6 | +35 12 30.5 |
| 39 | Lund | 34 | −00 52 44.97 | +55 41 51.6 |
| 67 | Lvov, Lemberg | | | |
| 513 | Lyon | 299 | −00 19 08.52 | +45 41 41.0 |
| 711 | McDonald Observatory | 2081 | +06 56 05.34 | +30 40 17.7 |
| 990 | Madrid | 655 | +00 14 45.10 | +40 24 30.0 |
| 14 | Marseilles (post-1864) | 75 | −00 21 34.55 | +43 18 16.3 |
| 27 | Milan | 120 | −00 36 45.89 | +45 27 59.2 |
| 998 | Mill Hill, London | 82 | +00 00 57.77 | +51 36 46.3 |
| 104 | Moscow | 166 | −02 30 16.95 | +55 45 19.8 |
| 414 | Mt. Stromlo | 768 | −09 56 01.35 | −35 19 16.0 |
| 672 | Mt. Wilson | 1742 | +07 52 14.33 | +34 12 59.5 |
| 532 | Munich | 529 | −00 46 26.02 | +48 08 45.5 |
| 330 | Nanking Purple Mt. | 367 | −07 55 17.02 | +32 03 59.9 |
| 19 | Neuchâtel | 488 | −00 27 49.79 | +46 59 50.6 |
| 20 | Nice | 376 | −00 29 12.10 | +43 43 17.0 |
| 801 | Oak Ridge, Harvard | | | |
| 86 | Odessa | 53 | −02 03 01.98 | +46 28 37.5 |
| 790 | Ottawa, Dominion Observatory | 87 | +05 02 51.95 | +45 23 38.1 |
| 533 | Padua | 38 | −00 47 29.15 | +45 24 01.3 |
| 535 | Palermo | 72 | −00 53 25.87 | +38 06 43.6 |
| 675 | Palomar | 1706 | +07 47 27.36 | +33 21 22.4 |
| 7 | Paris | 67 | −00 09 20.91 | +48 50 11.0 |
| 538 | Pola | 32 | −00 55 23.07 | +44 51 48.6 |
| 47 | Poznan, Poland | 85 | −01 07 30.78 | +52 23 54.3 |
| 79 | Pretoria | 1542 | −01 52 54.9 | −25 47 18 |
| 84 | Pulkovo | 75 | −02 01 18.57 | +59 46 18.5 |
| 34 | Rome, Monte Mario | 152 | −00 49 48.55 | +41 55 19.2 |
| | Rome | 51 | −00 49 55.12 | +41 53 53.6 |
| 110 | Rostov | | | |
| 795 | Rutherford, N. J. | | | |
| 983 | San Fernando | 30 | +00 24 49.30 | −36 27 42.0 |
| 804 | Santiago | 580 | +04 42 45.09 | −33 33 44.2 |
| 128 | Saratov | | | |
| 338 | Shanghai, Zo-Se | 100 | −08 04 44.75 | +31 05 47.6 |
| 94 | Simeis | 346 | −02 15 59.38 | +44 24 11.6 |
| 56 | Skalnaté Pleso | 1783 | −01 20 58.8 | +49 11 20.0 |
| 31 | Sonneberg | 640 | −00 44 46.19 | +50 22 41.4 |
| 191 | Stalinabad Tadjik | | | |
| 105 | Sternberg Observatory | | | |
| 50 | Stockholm | 55 | −01 13 14 | +59 16 18 |
| 25 | Stuttgart | 344 | −00 36 47.39 | +48 47 00.7 |
| 420 | Sydney | 44 | −10 04 49.19 | −35 51 41.1 |
| 75 | Tartu, USSR | 67 | −01 46 53.18 | +58 22 47.2 |
| 192 | Tashkent | 477 | −04 37 10.47 | +41 19 30.4 |
| 37 | Teramo, Italy | 398 | −00 54 56 | +42 39 27 |
| 388 | Tokyo, Mitaka | 59 | −09 18 10.10 | +35 40 21.4 |
| 777 | Toronto | 116 | +05 17 35.60 | +43 40 00.8 |
| 4 | Toulouse | 195 | −00 05 51.00 | +43 36 44.1 |
| 38 | Trieste (post-1898) | 67 | −00 55 05.23 | +45 38 35.5 |
| 692 | Tucson | — | −07 22 52 | +32 24 |
| 22 | Turin (Pino Torinese) | 618 | −00 31 05.95 | +45 02 16.3 |
| 62 | Turku, Finland | 28 | −01 28 55.03 | +60 27 08.7 |
| 12 | Uccle | 105 | −00 17 25.97 | +50 47 55.0 |
| 786 | U.S. Naval Observatory | 86 | +05 08 15.78 | +38 55 14.0 |
| 15 | Utrecht | 14 | −00 20 31.01 | +52 05 09.6 |
| 36 | Vatican | 450 | −00 50 36.33 | +41 44 47.4 |
| | Vienna (pre-1879) | 186 | −01 05 31.61 | +48 12 35.5 |
| 45 | Vienna (post-1879) | 240 | −01 05 21.35 | +48 13 55.1 |
| 558 | Warsaw | 121 | −01 24 07.26 | +52 13 04.6 |
| 786(1) | Washington National Observatory | 31 | +05 08 12.15 | +38 53 38.7 |
| 23 | Wiesbaden | | | |
| 754 | Williams Bay Yerkes | 334 | +05 54 13.24 | +42 34 12.6 |
| 70 | Wilno | 122 | −01 41 08.76 | +54 40 59.1 |
| 28 | Würzburg | 200 | −00 39 44.71 | +49 47 27.6 |
| 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 |
|---|---|---|---|---|
| 1 | $Abb_1$ | Abbadia | 1900 | Cat. of 14263 stars |
| 2 | $Abb_2$ | Abbadia | 1900 | Cat. of 13532 stars |
| 3 | Alg | Algiers | 1900 | Cat. of 9997 stars |
| 4 | AG Wash 00 | Washington | 1900 | −14° to −18° |
| 5 | AG Wash 00 | Washington | 1900 | −14° to −18° |
| 6 | AG | Berlin | | |
| 7 | AG W-Ott 00 | Wien-Ottakring | 1900 | −6° to −10° |
| 8 | AG Leip II 75 | Leipzig | 1875 | +10° to +5° |
| 9 | AG Alb 75 | Albany | 1875 | +5° to +1° |
| 10 | AG Strass 00 | Strassburg | 1900 | −2° to −6° |
| 11 | AG Nik 75 | Nikolajeiv | 1875 | +1° to −2° |
| 12 | Bo gem | Bonn | 1866 | *Ast. Nach.* No. 1540 |
| 13 | AOe 1842 | Wien | 1919 | +45° to +80° |
| 14 | L1 | | | |
| 15 | AW 1850 | Wien | 1890 | +15° to +31° |
| 16 | Kon 15 | Königsberg | 1815 | Bessel zone |
| 17 | B.A.C. | British Association Catalogue | | |
| 18 | BD | Bonn | 1855 | Bonn Durchmusterung |
| 19 | AG Berl A 75 | Berlin | 1875 | +20° to +15° |
| 20 | AG Berl B 75 | Berlin | 1875 | +25° to +20° |
| 21 | BX | | | |
| 22 | 2. Bord | Bordeaux | 1900 | +10° to +18° |
| 23 | CC Bord | | | |
| 24 | Cbr E | Cambridge (England) | 1875 | +25° to +30° |
| 25 | Cbr M | Cambridge (Mass.) | 1875 | +50° to +55° |
| 26 | Cod S | Cordoba | 1893 | Zodiacal Catalogue and General Catalogue |
| 27 | C.A.G. | | | |
| 28 | Ya | Washington | 1860 | Third edition |
| 29 | $12y_{45}$ | Greenwich | 1845 | 12-year catalogue |
| 30 | 7y | Greenwich | 1860 | 7-year catalogue |
| 31 | N7y | Greenwich | 1864 | New 7-year catalogue |

## Table 2 (contd)

| Code | Abbreviation | Location | Date | Observation |
|---|---|---|---|---|
| 32 | 9y | Greenwich | 1872 | 9-year catalogue |
| 33 | H.C. | | | |
| 34 | Hyderabad | | | |
| 35 | Kli 1860 | Göttingen | 1891 | two volumes |
| 36 | | | | |
| 37 | Dr. Forster | Berlin Observatory | | |
| 38 | Lalander | Berlin Observatory | | |
| 39 | Lam | Munich | 1850 | 2112 small stars |
| 40 | Grb | Groombridge | 1810 | |
| 41 | Lpz II | Leipzig | 1875 | +5° to +10° |
| 42 | Kri | Kristiana | 1900 | +65° to +70° |
| 43 | MaP | Madras | 1875 | New General Catalogue |
| 44 | $Mu_1$ | Munich | 1880 | |
| 45 | New Standard Zodiacal | Washington | 1850 | Clock and zodiacal |
| 46 | W-Ott 90 | Wien-Ottakring | 1890 | 1238 stars |
| 47 | Oxf. Plot | | | |
| 48 | $Par_1$ | Paris | 1845 | |
| 49 | Sj | Schjellerup | 1865 | −15° to +15° |
| 50 | $Strb_2$ I | Strassburg | 1885 | 2 volumes |
| 51 | $SF_{92}$ | San Fernando | 1892 | |
| 52 | Fundamental Stars | | 1866 | Dr. Gould |
| 53 | Toul B $o^h$... $1^h$.. | Toulouse | 1900 | photographic |
| 54 | W | Weisse | 1825 | −15° to +15° |
| 55 | $W_2$ | Weisse | 1825 | +15° to +45° |
| 56 | Wash Cat. | Washington | 1882 | 73, 78 |
| 57 | Hedr | Washington | 1900 | zodiacal stars |
| 58 | Yale | New Haven | 1950 | 21 volumes |
| 59 | | | | |
| 60 | Weisse Lan XI | | | |
| 61 | Gr. | | | observed by Johnson |
| 62 | R | | 1840 | Catalogue of Reslhuber |
| 63 | Challis | | | |
| 64 | $Do_{50}$ M | Dorpat | 1850 | *Bonn Durchmusterung* XVI |
| 65 | Nautical Alma. | | 1858 | Pisce |
| 66 | Ru H | Hamburg | 1845 | |
| 67 | Lal | London | 1800 | F. Baily |
| 68 | KZA | Königsberg | 1825 | 1309 stars |
| 69 | $San_1$ | Padova | 1840 | 0° to +10° |
| 70 | Sievers | | | |
| 71 | | | | |
| 72 | Wien Meridian | | 1860-65 | |
| 73 | Pulk 65 | Pulkova | 1865 | Vols. XII, XIV |
| 74 | WB | | | Weisse, B |
| 75 | Rbg | Pulkova | 1875 | Romberg Meridian |
| 76 | Lei Mer Obs | | 1865 | |
| 77 | Lorak | | | |
| 78 | W Pal | Wien | 1875 | 3458 stars |
| 79 | Berl | Berlin | 1865 | 2338 stars |
| 80 | CB | Göttingen | 1875 | −0° to −1° |
| 81 | Rob | Armagh | 1840 | 5345 stars |
| 82 | Berl A | Berlin | 1875 | Meridian |
| 83 | Lamont (3) | | | |
| 84 | $San_5$ | Trettenero | 1860 | 0° to +3° |
| 85 | Bo VI | Bonn | 1855 | |
| 86 | Kgb | | 1881 | Meridian observation |
| 87 | Cp | Cape | 1840-90 | |
| 88 | | Meridian Obs. Bonn; Scheivar | | |
| 89 | Gl | Glasgow | 1870 | Grant's list |
| 90 | $M_1$ | Hamburg | 1844 | |
| 91 | Port | | | |
| 92 | Pu M | Pulkova | 1855 | Meridian |
| 93 | A.We. | | | |
| 94 | $Par_2$ | Paris | 1860 | |
| 95 | $RC_3$ | Cambridge | 1875 | Third Radcliff |
| 96 | | | | |
| 97 | Karlsruhe | | | |
| 98 | $Ru_2$ | | | |
| 99 | $Par_3$ | Paris | 1875 | |
| 100 | Hels | Helsingfors | 1875 | +55° to +65° |
| 101 | | | | |
| 102 | $Abb_3$ | Abbadia | 1900 | 7443 stars |
| 103 | Lic Schl | | | |
| 104 | C.C. Alg | | | |
| 105 | Dr. Winnecki Meridian Observations | | 1863 | |

**Table 2 (contd)**

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

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 meaning 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.

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

## Table 3. Transit circle observers

| Source code | Observer | Observed | Instrument | Observatory | GPF[a] code | Source code | Observer | Observed | Instrument | Observatory | 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. Rhynsburger | 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. Rhynsburger | 1956– | 6 in. | USNO | 8 |

[a]GPF = General Planetary Format.

Table 3 (contd)

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

**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 | None | I, II, C | N, S, C |
| | 7 = Saturn, Uranus, Neptune | | C | C |
| XV, Part V | 8 = sun | 1 to 5 | — | — |
| | 8 = planets | 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 |

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 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 | | 210-ft Mars Site—DSS 14[d] | Antenna | 6372.0527 | 35.425 9278 | 35.244 4061 | 243.111 3473 |
| 030 | Tyngsboro, Mass[e] | Lincoln Laboratories—Massachusetts Institute of Technology Haystack site | Antenna | 6368.5517 | 42.623 194 | 42.431 518 | 288.511 333 |
| 031 | Westford, Mass. | 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 |

[a]Geocentric coordinates computed using the following values: $\rho = 6378.165$ km, $1/f = 298.3$.

[b]Antenna implies that this location was both a transmitter and a receiver.

[c]Muhleman, 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.

[d]JPL Coordinates for Goldstone: DSS 13 and DSS 14, Jay Curtright, May 1, 1968.

[e]Massachusetts 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," *Astron. J.*, 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., *Compression of JPL Venus Radar Data*, 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," *Astron. J.*, Vol. 70, No. 7, 1965 |
| J005 | Dyce, R. B., and Pettengill, G. H., "Radar Observations of Mars and Jupiter at 70 cm," *Astron. J.*, Vol. 72, No. 6, 1967 |
| J006 | Evans, et al., "Radar Observations of Venus at 23 cm in 1965/1966," *Astron. J.*, 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., *Reconstructed Data Preliminary*, 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

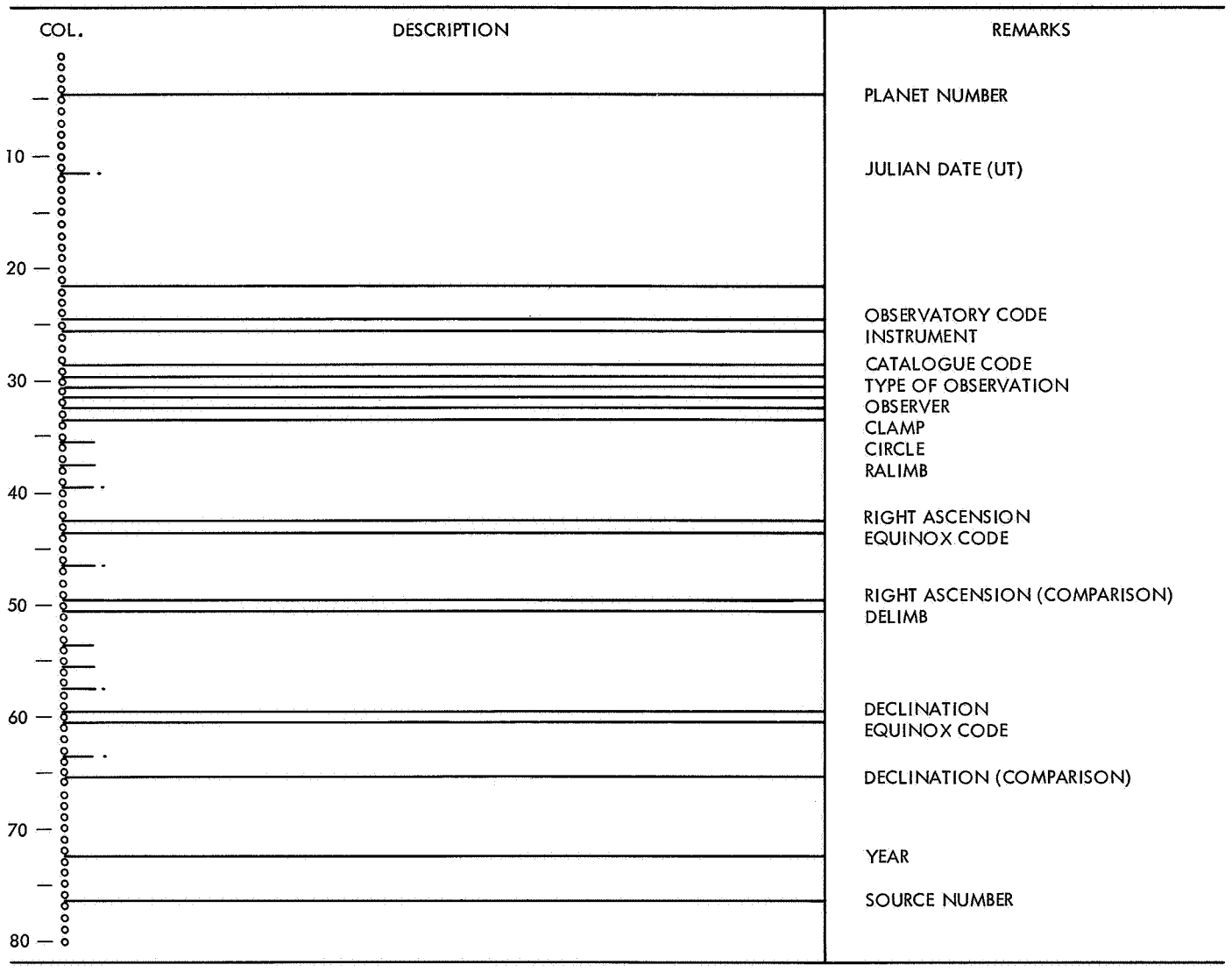


**Fig. A-1. Optical card—revision 2**

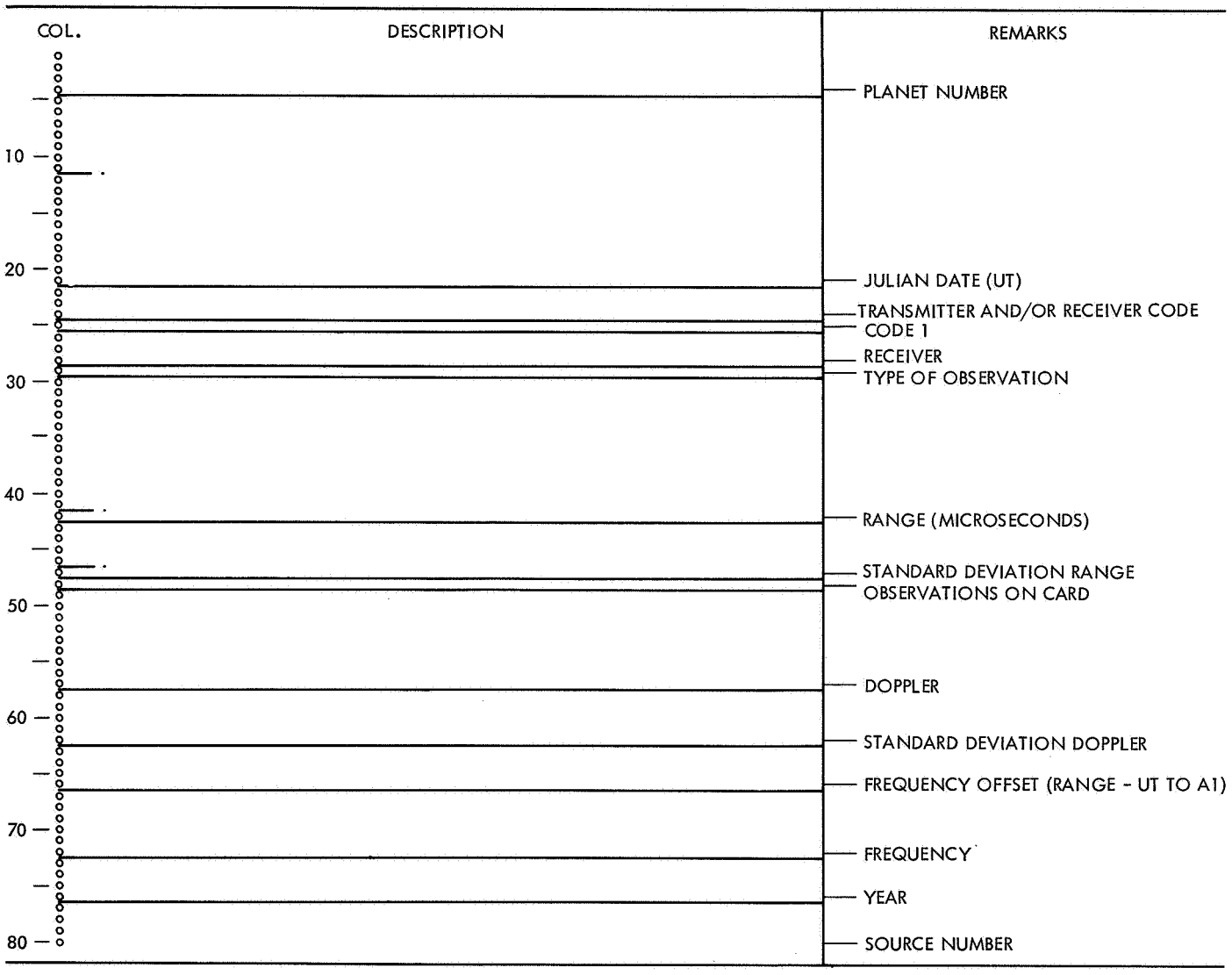


**Fig. A-2. Radar data card—revision 3**

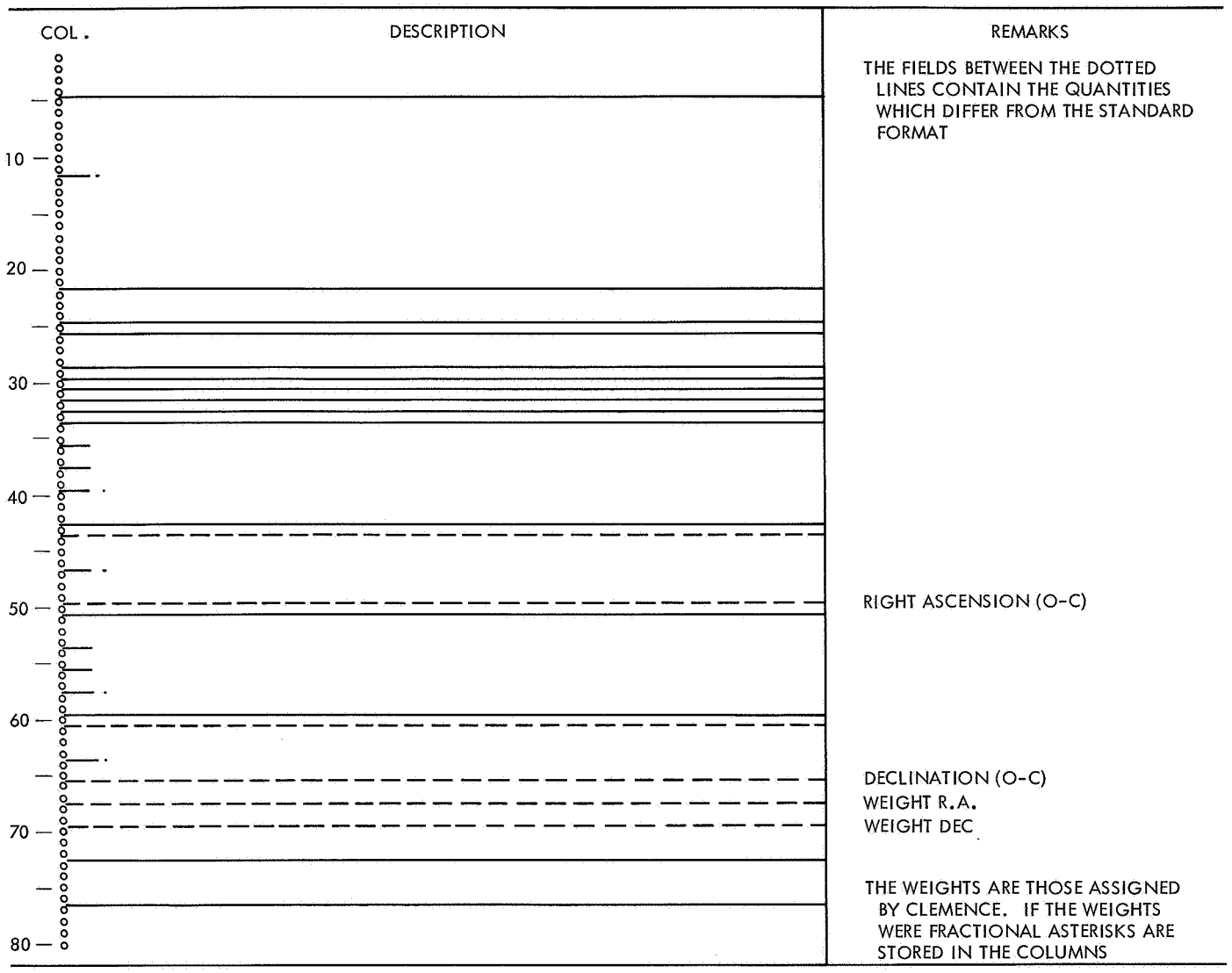


**Fig. A-3. Optical card for USNO Mercury optical observations—revision 2 (modified)**