

#### 4. COMMISSION DES EPHEMERIDES

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The General Assembly, at its meeting in 1964, adopted the following Resolution No. 4, which had been proposed by a joint discussion of Commissions 4, 7, 8, 19, 20, and 31: 'The International Astronomical Union endorses the final list of constants proposed by the Working Group on the System of Astronomical Constants and recommends that it be used in the national and international astronomical ephemerides at the earliest practicable date.'

The report of the Working Group mentioned and the proceedings of the joint discussion have been published in *Transactions of the International Astronomical Union*, Volume XIIB, pages 591-625.

The appended reports of the various offices preparing ephemerides show the extent to which it has so far been practicable to introduce the new system of constants. While excellent progress has been made, a few troublesome questions remain, most of them relating to the basic ephemerides of the Sun and Moon and the definition of Ephemeris Time.

The principal accomplishments so far effected may be summarized as follows:

The revised apparent places of fundamental stars are introduced as from 1968 as are also the day numbers for the reduction of stars from mean place to apparent place. For the ephemerides of the Sun, Moon, and planets, differential corrections (or simple formulae from which they may be calculated) are provided in those cases where the corrections are appreciable, also as from 1968. So far it has not been practicable to modify the planetary ephemerides so as to include the effect of the new mass-ratio of the Sun to the Earth and Moon. Furthermore, the new value of the constant of aberration has not been introduced into the ephemerides of the Sun, Moon, and planets, nor into the measure of Ephemeris Time. Questions relating to these matters will be discussed at the meeting of the Commission.

G. M. CLEMENCE  
*President of the Commission*

#### APPENDIX: REPORTS OF THE DIRECTORS OF THE NATIONAL EPHEMERIDES

*Instituto y Observatorio de Marina, San Fernando (Cadiz), Spain*

The work in this Ephemeris Office has been to continue the publication of the 'Ephemerides Astronómicas', the 'Almanaque Nautico' and the 'Almanaque Aeronautico', with little modifications not being worth mentioning.

VICENTE PLANELLES



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*Fundamental Catalogue.* Reports on the formation of FK<sub>4</sub> were given by Gliese (1) and Kopff, Nowacki, and Strobel (2). Formulae and tables for the reduction of small proper motions and co-ordinate differences, which had been used in the construction of FK<sub>4</sub>, were published by Kopff, Nowacki, Strobel and Mürle (3). For the reduction of positions and proper motions of GC and N<sub>30</sub> it is suggested to use the tables of systematic differences FK<sub>4</sub>-GC and FK<sub>4</sub>-N<sub>30</sub> computed by Brosche, Nowacki and Strobel (4). Heinemann (5) compiled a list of star catalogues from 1900 to 1962 which is a continuation and supplement to previous lists.

In preparation of further improvements of the fundamental catalogue and of a revision of the GC an analytical method for deriving systematic differences in star positions between different catalogues was developed by Brosche (6). This method is applicable in machine computation. In continuation of previous work, and in co-operation with the U.S. Naval, the Yale, and the Potsdam-Babelsberg Observatories many star catalogues have been placed on punch cards.

Further information on the fundamental catalogue and related subjects is given in the Report of Commission 8.

*APFS and exchange of ephemerides.* Within the period under review four volumes of 'Apparent Places of Fundamental Stars' were published (1965-68). Within the year 1967, the volumes for 1969 and 1970 will appear. In view of the early appearance of the volumes it is recommended again that the data may be photomechanically reproduced by Ephemeris Offices wishing to include apparent places of stars in their almanacs.

As recommended by IAU Commission 4 (*Trans. IAU*, 12B, 105), the new value of the constant of aberration adopted in the IAU System of Astronomical Constants was introduced in the APFS from the volume 1968 onwards. Since in the IAU System of Astronomical Constants the constants of precession and nutation remained unchanged, the calculation of apparent star places is affected by the revision of the constant of aberration only. For the reduction of observations made before and after 1968, observers are advised to use the formulae given in APFS 1968, page v, for reducing the star places of the previous volumes of APFS to the new value of the aberration.

The apparent places of all stars included in FK<sub>4</sub> Sup (7) have been computed at Heidelberg from the year 1965 onwards. They will not be published, but are available to observers on request. They are definitely not recommended for inclusion in national ephemerides.

The communication of apparent and mean places to Ephemeris Offices has been continued. The number of recipients has increased from 14 to 19 by the addition of the following institutions: Observatorio Astronomico Nacional (Bogotá), Observatorio Astronomico (Coimbra), Direktorat Hidrografi Angkatan Laut (Djakarta), Hidrografski Institut, Jugoslavenski Ratne Mornarice (Split), Institut für Meereskunde (Warnemünde).

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W. FRICKE

*Nautical Almanac Office, U.S. Naval Observatory, Washington, D.C., U.S.A.*

The Nautical Almanac Office is responsible for the publication of four annual ephemerides, the American Ephemeris—for astronomers, the Nautical Almanac—for surface navigation, the Air Almanac—for air navigation, and the Ephemeris—for land surveyors, as well as the pamphlet *Astronomical Phenomena*.

The American Ephemeris and Nautical Almanac, unified with the Astronomical Ephemeris issued by H.M. Nautical Almanac Office, Royal Greenwich Observatory commencing with the volume for 1960, has continued to be published.

Beginning with the year 1968 the IAU System of Astronomical Constants (*Trans. IAU*, **12B**, 105, 1966), was introduced wherever practicable. An explanation of these constants with references and formulae was printed in the *Supplement to the A.E. 1968*, 'The Introduction of the IAU System of Astronomical Constants'. This supplement was included in the 1968 edition and also published separately. A section in this supplement is devoted to the changes in, and corrections to, the Explanatory Supplement to the Astronomical Ephemeris and the American Ephemeris and Nautical Almanac, due to the introduction of the IAU System of Astronomical Constants. Also in the 1968 edition, the new position of the north pole of Mars was adopted in the computation for the Physical Ephemeris (1).

In cooperation with the U.S. Naval Oceanographic Office and H.M. Nautical Almanac Office a new set of *Sight Reduction Tables for Marine Navigation* is being designed and produced (*Navigation*, **13**, 97, 1966). Volumes 4, 5 and 6 are now being photo-composed. The remaining volumes are being computed. Extension of the computer-controlled photo-composition method to the Air Almanac and portions of the American Ephemeris is planned for the near future.

The navigational almanacs have continued to be published with minor changes. Beginning with 1965 the precision of the Sun and stars in the Air Almanac was increased to 0.1.

The preparation of advance predictions of solar eclipses in accordance with the recommendation of the International Astronomical Union has been continued (2, 3). Circumstances of solar eclipses with argument in U.T. have also been prepared (4, 5, 6).

Progress of a cooperative project with Yale University Observatory to put star catalogs in machine readable form has been continued (7, 8).

The special Ephemeris of the Radio Longitude of the Central Meridian of Jupiter, System III (1957.0) is being continued for the years 1968–71.

Additional astronomical information has been prepared and published to meet public demand (9, 10, 11).

A new electronic computer, the IBM 360/40 with four magnetic tape units was installed, in August 1966, in the new G. W. Hill Scientific Computing Center.

The research project on the motions of the principal planets conducted jointly by Yale University Observatory, the Watson Scientific Computing Laboratory and the U.S. Naval Observatory has been continued (12, 13, 14, 15, 16).

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R. L. DUNCOMBE

*H.M. Nautical Almanac Office, Royal Greenwich Observatory,  
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The Office has continued, without substantial change, the production of the four ephemerides:

*The Astronomical Ephemeris*—for astronomers,  
*The Nautical Almanac*—for surface navigation,  
*The Air Almanac*—for air navigation,  
*The Star Almanac*—for land surveyors.

The first three ephemerides are completely unified with the corresponding U.S. editions, which are printed separately from identical reproducible material; this material can be made available, at a small charge, to the official almanac-producing agency in any other country that desires to publish similar ephemerides in this form.

Advanced proofs of the first part of *The Astronomical Ephemeris* have been circulated to ensure that the tabulated data are available, in ample time, to all agencies responsible for the preparation of navigational and other almanacs.

As recommended by Commission 4, at its meeting in Hamburg on 28 August 1964 (*Trans. IAU*, 12B, 105, 1966), the IAU System of Astronomical Constants was introduced into *The Astronomical Ephemeris* for 1968, in so far as this was practicable. A thorough study of the effects of the introduction of the new system on the ephemerides has been included in the *Supplement to the A.E. 1968*; copies of the Supplement are included in the A.E. 1968, and are also available separately on application. The full effects of the changes have been incorporated only in the tabulations of the Day Numbers, for the Observatories and for Table VII (the factors *S* and *C*), and formally (since the changes are not significant to the tabular precision) in the ephemeris for the physical observation of Mars, for satellite V of Jupiter and for the satellites of Uranus and Neptune. For all other ephemerides, for which the corrections are appreciable, differential corrections, or simple formulae from which such corrections can be calculated, are included in an appendix (*Formulae and Corrections for Conversion to the IAU*



*System of Astronomical Constants*), so that the printed ephemerides can be readily converted to the new system.

As envisaged at the meeting in Hamburg, it has proved to be impracticable to incorporate the changes in the ephemerides of the planets due to the changed value of the mass ratio  $S/(E + M)$ . Further, pending international discussion of, and agreement on, the possible redefinition of the epoch of Ephemeris Time, it was decided not to introduce the effect of the change in the adopted value of the constant of aberration either into the measure of E.T. or into the ephemerides.

As from the edition of 1969, it has been found possible to include the full effects of the changes in all ephemerides other than the fundamental ephemerides of the Sun, Moon and planets; these are already in print and it has been considered adequate to give differential corrections, or formulae for them, in an appendix. Differential corrections for the ephemeris of the Moon have been evaluated for the years 1968 to 1971, and it is possible that a corrected ephemeris for the Moon will be introduced in *The Astronomical Ephemeris* for 1972.

Considerable thought has been given to the possible redesign of *The Astronomical Ephemeris* to accord more with current requirements; but present indications are that the only resulting changes will be some additions, particularly in respect to geocentric distances, and some consequential rearrangements. It is hoped that, by 1972, the fundamental ephemerides will be printed from computer-controlled photo-set copy.

A new electronic computer, the ICT 1909, with punched-card and punched paper-tape input and output, and with four magnetic tape units, was installed in May 1966; this will, in due time, make practicable the systematic calculation and storage, in machine-readable form, of the fundamental ephemerides of the Sun, Moon and planets in accord with the theories and constants as adopted by the Commission.

As from the editions for 1965, an increased precision (of 0.1) has been included in the ephemerides of the Sun and the stars in *The Air Almanac*; some other additions, changes and consequential rearrangements were also made. No changes have been made in the other publications. But the Office has cooperated with the U.S. Naval Oceanographic Office and the Nautical Almanac Office at the U.S. Naval Observatory in the design and production of a new set of *Sight Reduction Tables for Marine Navigation* (*J. Inst. Navig.*, 19, 281, 1966).

The prediction of occultations by the Moon and planets has been somewhat extended, particularly in respect of the radio sources. A comprehensive programme for the prediction of lunar occultations is now available on the new ICT 1909 computer.

As part of the British contribution to the tracking and orbital analysis of artificial satellites, the Office is providing a comprehensive service of 'look-data' predictions for selected satellites and stations; as a result of this service, the number of useful observations has been more than doubled. Special ephemerides have also been supplied for the use of radio astronomers.

The Office is currently celebrating the two-hundredth anniversary of the first publication of *The Nautical Almanac and Astronomical Ephemeris*; this was prepared and published by the fifth Astronomer Royal, Nevil Maskelyne, in 1766 for the year 1767. It made practicable the method of lunar distances for the determination of longitude at sea. To mark this event, special supplements were included in both *The Astronomical Ephemeris* and *The Nautical Almanac* for 1967.

D. H. SADLER

*Bureau des Longitudes, Paris, France*

Le travail de rédaction des publications du *Bureau des Longitudes* a été poursuivi au cours des trois dernières années selon un rythme analogue à celui des périodes précédentes. Le contenu de la *Connaissance des Temps* n'a pas subi de modifications autres que celles qui ont



été annoncées dans le dernier rapport et la présentation, depuis 1966, du système UAI de constantes astronomiques.

Par suite l'automatisation des calculs et des procédés d'impression, les intervalles de tabulation des données concernant les planètes seront iniformisés à partir de la *Connaissance des Temps* pour 1968: de jour en jour pour l'ascension droite et la déclinaison de toutes les planètes, de 2 jours en 2 jours pour les coordonnées écliptiques héliocentriques et géocentriques (sauf Mercure qui conserve la périodicité de 1 jour).

A partir de 1968, les constantes pour la réduction des étoiles seront publiées avec la valeur de la constante de l'aberration du système UAI. Les coordonnées des observatoires et les données relatives à l'ellipsoïde terrestre seront aussi ramenées à ce système. Par contre, aucun changement dans les valeurs numériques servant à calculer les éclipses et les éphémérides du Soleil, de la Lune et des planètes ne sera introduit *au moins jusqu'en 1971* et les éphémérides publiées ne présenteront donc aucune discontinuité avant cette date. Des tables donnant les corrections aux éphémérides de la Lune pour les rendre compatibles avec le système UAI seront publiées à partir de 1968.

Depuis septembre 1965, le *Bureau des Longitudes* est équipé d'un ordinateur électronique Bull Gamma 30 S à disques magnétiques. Tous les calculs des tables publiées par la *Connaissance des Temps* et les *Ephémérides Nautiques* sont calculés sur cette machine. La publication des résultats des calculs ainsi programmés sera effective dans sa totalité à partir de la *Connaissance des Temps* pour 1968. Un convertisseur de bandes SEA, permettant de convertir des bandes à 7 canaux perforés par l'ordinateur en bandes Monotype commandant la fonte des caractères, a été mis en fonction en avril 1966. Il assurera dans l'avenir l'impression automatique de tous les tableaux de nos publications. Déjà, 164 pages de la *Connaissance des Temps* pour 1967 ont été composées de cette manière et ce nombre s'accroîtra d'année en année. La moitié des *Ephémérides Nautiques* pour 1968 seront composés par le même procédé.

Parallèlement, au Bureau des Longitudes il a été effectué des recherches concernant les tables du Soleil de Le Verrier et le temps employé dans ces tables (1). Un grand effort est aussi déployé vers l'étude du problème des satellites de Jupiter (2) avec l'espoir d'obtenir des tables provisoires qui pourraient améliorer celles de Sampson en attendant qu'un nombre d'observations modernes suffisant permette de construire une théorie complète entièrement nouvelle.

Aucun changement n'est intervenu dans la présentation des *Ephémérides Nautiques* et les *Ephémérides Aéronautiques*.

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Pour A. DANJON,  
J. KOVALEVSKY

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During the period under review four issues of the 'Astronomical Almanac of the U.S.S.R.' for the years 1967, 1968, 1969, 1970 have been published. The positions and proper motions of stars are given in the FK4 system as decided by Commission 4 (Ephemerides) at the XIth IAU Meeting (Berkeley, 1961).

In accordance with the recommendations of the IAU adopted at the XIIth Meeting (Hamburg, 1964) some ephemerides have been based on the IAU System of Astronomical Constants.



As the above mentioned resolutions of the IAU envisaged the introduction of the IAU System of Astronomical Constants beginning with ephemerides for 1968 the corresponding differential corrections as well as recomputed ephemerides have been published in the Appendices to the Astronomical Almanacs of the U.S.S.R. for the years 1969 and 1970.

An ephemeris of the lunar crater Mösting A has been regularly published in these issues of the Astronomical Almanac of the U.S.S.R. being based from 1969 onwards on the corrected formulae due to F. Hayn and K. Koziel.

Ephemerides of the Sun, Moon and planets have been printed in full conformity with the first part of the Astronomical Ephemeris circulated in advance by the British Nautical Almanac Office, the corrections for the transform to the IAU System of Astronomical Constants being listed in the Appendix to the Astronomical Almanac of the U.S.S.R. for the year 1970.

The navigational almanacs have been regularly published as before. The Nautical Almanac has been issued for the years 1966, 1967, 1968, 1969, and the Air Almanac for 1965, 1966, 1967, 1968.

Computations of right ascensions of 664 stars for the Soviet Time Service programme for the epoch 1970·0 have been completed and published (1).

Investigations concerning the methods of computations of the ephemerides of the Moon and planets as well as ones dealing with estimation of the accuracy of planetary ephemerides have been continued (2-5).

A series of papers coupled with elaboration of analytical theories of planetary motion as well as with numerical methods of Celestial Mechanics should also be mentioned as forming the basis for use in computation of ephemerides (6-13).

Several papers were devoted to research on a new theory of the physical libration of the Moon (14, 15) and to the use of high-speed computers for prediction of solar and lunar eclipses (16).

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The Japanese Ephemeris has continued to be published for the years 1966 to 1968. The ephemerides of the Sun, Moon and planets have been reproduced from the advanced proofs of the Astronomical Ephemeris provided by the H.M. Nautical Almanac Office, and the mean places of 1535 fundamental stars have been provided by the Astronomisches Rechen-Institut, Heidelberg; the remaining parts have been computed in the Hydrographic Office.

From the volume 1968 the new IAU System of Astronomical Constants is adopted for computation of day numbers and apparent places of circumpolar stars. Correction tables or formulae for reduction to the new system are shown at the end of the volume.

*The Nautical Almanac*, the *Abridged Nautical Almanac* and the *Polaris Almanac for Surveying* for the years 1965 to 1967 have continued to be published without substantial change.

In view of the reopening of the antarctic expedition *The Altitude-Azimuth Almanac* has been compiled for 1965 to 1967; it shows the apparent altitude and azimuth of the Sun at  $69^{\circ}00'22''S$ ,  $39^{\circ}35'24''E$ . At the request of the National Defence Agency the *Abstract from the Japanese Ephemeris* has been compiled annually, showing apparent places of bright stars and some data for the Sun.

A program for enlarging the computer HIPAC 103, whose main parts were installed in 1963, will be completed by the end of March 1967, and international and domestic exchanges of computational data will be possible afterwards.

The value of  $\Delta T$  for use in predictions of eclipses and the compilation of almanacs has been settled by arrangement with the Tokyo Astronomical Observatory from results of occultation observations made at both institutes (1, 2, 3).

Constant difficulty exists in keeping the list of Standard Times in the almanacs up to date because of lack of an international channel of information.

In May 1966, it was resolved by the National Committee of Astronomy, Science Council of Japan, that computations of apparent places of stars for various investigations in positional astronomy in Japan should be carried out at a specified institute using theoretically rigorous formulae. And the Hydrographic Office agreed officially to take over this responsibility. The work is to begin by the end of March 1967. Concerning this work Inoue (4) treated the effects of coordinate-transformations on the *E*-terms of day-numbers *C* and *D*.

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A. M. SINZI



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During the period under review, two volumes of the Indian Ephemeris and Nautical Almanac, viz., for 1966 and 1967, have been published. The issue for 1968 is expected to be published by January 1967.

No material change in respect of the contents of the publication has been introduced during these years except that calendars of the Jews and Indian Parsis have been added in Part V from the 1967 issue.

As regards the IAU System of Astronomical Constants recommended at the XIIth General Assembly, the revised value of the flattening factor for Earth, viz.  $1/298.25$ , has been introduced in the volume for 1968 and the relevant tables have been revised. The prediction of local circumstances of eclipses and occultations have also been done on this basis. The ephemerides of the Sun, Moon and planets are given in conformity with the first part of the Astronomical Ephemeris. In tabulating the solar parallax and solar aberration revised values of  $8''.794$  and  $20''.496$  respectively have been used, but the effect of the latter has not been included in the ephemerides of the apparent place of the Sun. The values of the Day Numbers  $C$  and  $D$  as revised on the basis of the new aberration constant have been used from this issue.

Detailed local predictions of eclipses with maps for the Annular Solar Eclipse of 23 November 1965, and the Annual Solar Eclipse of 20 May 1966 as visible in India were made.

In addition to the above-mentioned main publication the following two other publications continue to be issued annually.

1. Tables of Sunrise, Sunset and Moonrise, Moonset—a reprint from the Indian Ephemeris and Nautical Almanac. The issue for 1967 was published in 1966.
2. Rashtriya Panchangs in twelve languages, viz. in English, Sanskrit, Hindi and nine regional languages of India giving details of the Indian Calendar. The issues for 1880 Saka era (1966–67 A.D.) were published in 1966.

A new item of work undertaken is the editing and publication of an English translation of Dixit's Bharatiya Jyotish-Sastra, a notable book in Marathi language on the history of Indian astronomy.

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