# 4. COMMISSION DES EPHEMERIDES

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MEMBRES: Fayet, Fernandez de la Puente, Kahrstedt, Kopff†, D. K. Kulikov, Lahiri, Sadler, Woolard.

## SURVEY OF PROGRESS

### *Introduction*

In thinking about the efficiency of an IAU Commission it is gratifying to observe that the recommendations of Commission 4 made during the last decades have resulted in a very effective improvement of the bases of the ephemerides and in a conformity of published ephemerides which is not only desirable but necessary for further progress in research. The reports of the Directors of the national ephemerides which are included in the Appendix to this report show in more detail how agreed improvements have been introduced into the production of the national ephemerides during the last years. At present, no immediate action seems necessary to eliminate further inconveniences. However, there are various problems which can be furthered by discussion in the Commission. It is the purpose of this report to draw attention to these problems. No attempt will be made to review the various improvements in the production of the ephemerides as they are consequences of agreed recommendations, nor to give a bibliography of published papers.

A few comments may be permitted on the list of reports of the Directors of the national ephemerides. There is one omission and one addition as compared with former lists. Omitted is the Astronomisches Recheninstitut, Potsdam-Babelsberg, which coincident with the cessation of the *Berliner Astronomisches Jahrbuch* has become a division of the Babelsberg Observatory. As far as activity in the field of the Commission is concerned the Observatory is continuing to carry out calculations of special local interest, *e.g.* solar eclipse data for geophysicists. Added to the list is the Nautical Almanac Unit of the India Meteorological Department, Calcutta, which is publishing the *Indian Ephemeris and Nautical Almanac*.

### *National ephemerides and exchange of data*

The identity (except for the title) of *The American Ephemeris and Nautical Almanac* and the (British) Nautical Almanac, newly entitled *The Astronomical Ephemeris*, as from the editions for the year 1960, has to be considered as an important step towards unification of the national ephemerides. G. M. Clemence and D. H. Sadler (1) write:

'Many dearly-held, but essentially unimportant, standards and prejudices have had to be sacrificed on both sides; it is surprising how quickly these lose their former importance in the satisfaction of a comprehensive agreement. That same co-operation, goodwill and confidence exists between all the national ephemeris offices, and, although differences of language will introduce some further difficulties, there is no obstacle to complete unification that will not be overcome in course of time.'

Although it seems still too early for the ultimate achievement of a single international astronomical ephemeris these words of Clemence and Sadler should have an encouraging effect.

Reproducible material of the unified Ephemeris can be made available to the Offices of other

national ephemerides, upon payment of a nominal charge for preparation. At present many Offices already use the data from advanced proofs which they readily obtain. As can be seen from the report of the Astronomisches Rechen-Institut, Heidelberg, the same use is being made of the apparent places of fundamental stars which are being made available before publication of the international volume *Apparent Places of Fundamental Stars* (APFS).

At the tenth General Assembly the President of Commission 7 was authorized by Resolution no. 12 (**2**) to form a Committee to consider the exchange of astronomical data on punched cards or any machine-readable form. The Commission could possibly assist this Committee in making appropriate proposals. One example is perhaps the important volume *Planetary Co-ordinates for the years* 1960–1980 *referred to the equinox of* 1950·0, prepared and published by the British Nautical Almanac Office, which is needed at various places in machine-readable form, another example, the new Fundamental Catalogue FK 4.

*Determination of Ephemeris Time*

During the last years the problem of the determination of Ephemeris Time was treated by several authors (**3, 4, 5, 6**). Experience shows that the annual values of $\Delta T$, the correction to be applied to Universal Time to give Ephemeris Time, should be internationally agreed. At present there are a number of different values being used, for instance, depending upon the precise equinox correction and also on whether corrections are applied for the difference between the actual flattening of the Earth and the value (1/294) used by Brown in his theory. D. Brouwer and D. H. Sadler propose that this question be discussed at the General Assembly. It may turn out that a small Committee including members of other Commissions should be formed to work out a report so that an agreement can be reached in 1964.

*Introduction of FK 4 into the APFS*

According to Resolution no. 59 of the tenth General Assembly (**7**) the determination of Universal Time shall be based on the system FK 4 commencing with the first of the year following publication of corrections to individual mean positions of fundamental stars which transform FK 3 positions into those of FK 4.

Since the FK 4 will be completed in the year 1961, it is to be expected that corrections FK 4 *minus* FK 3 for the year 1962, which can directly be added to the apparent places in the volume APFS for the year 1962 to give the apparent places on the FK 4 will be published in time. All the users of the volume APFS will obtain the list of these corrections. A definite statement will be made at the General Assembly.

At present it can be regarded as possible but not certain that the first volume of APFS to contain the printed values of apparent places based on the FK 4, will be the volume for 1964. On this point also a definite statement will be made at the General Assembly.

*List of fundamental constants*

It has been suggested that the IAU should make itself responsible for keeping an up-to-date list of the best astronomical constants. If the Commission approves of this suggestion the procedure should be discussed to set up a list of those constants which are of importance for the computation of predictions.

*Ephemeris problems relating to artificial satellites*

The International Council of Scientific Unions (ICSU) has given much thought to the continuation of peaceful activities in outer space after the end of the IGY. The General Assembly of ICSU decided therefore to set up a Committee of Space Research (COSPAR),

whose governing bodies were established in November 1958. Since COSPAR has started activities, it can be expected that it will contact Ephemeris Offices on problems which exist in connection with the calculation of ephemerides for these bodies and the problem of Space Navigation.

At the Moscow meeting it was the agreed opinion of Commission 4 that the launching countries should be responsible for the provision of ephemerides. At present it still seems reasonable to maintain this attitude.

There exists a possible application of an artificial satellite as a navigation satellite which would naturally become of special interest for this Commission. The report *The United Nations and Peaceful Uses of Outer Space* (**8**) draws attention to this new possibility with the following statement: 'The navigation satellite may provide the basis for an all-weather long-range navigation system for surface vehicles and aircraft. With the use of suitable ranges of frequencies for transmission, it would be possible to establish positions with great precision irrespective of the prevailing weather. At the present time, there is no such world-wide all-weather system of navigation.'

With the launching of space vehicles the problem of space navigation will have to be tackled. A popular report which clearly shows the various difficulties of measuring positions and velocities from a space vehicle was published by J. G. Porter (**9**). It may well be that the volumes of *Planetary Co-ordinates* will have to play the role of the future *Space Almanac*.

W. FRICKE
*President of the Commission*

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

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

The *Almanaque Nautico*, *Almanaque Nautico para uso de los Navegantes* and *Almanaque Aeronautico* have been published regularly, with only minor modification. From 1961 the *Almanaque Nautico* will be titled *Efemerides Astronomicas*.

FRANCISCO FDEZ. DE LA PUENTE

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

Beginning with the volume for 1960, *The American Ephemeris and Nautical Almanac* was made identical with *The Astronomical Ephemeris* issued by H.M. Nautical Almanac Office, Royal Greenwich Observatory, except for the title and a few of the introductory pages. This completed the unification of the annual astronomical and navigational ephemerides issued by

these two Almanac Offices which was begun with *The Air Almanac* for 1953. The new title *The Nautical Almanac* replaced the former titles *The American Nautical Almanac* and *The Abridged Nautical Almanac* of the volumes for surface navigation, which except for title had been identical beginning with 1958.

The navigational almanacs have continued to be published without substantial change; but in *The American Ephemeris* a large number of revisions were made in 1960. The principal changes are for the purpose of conforming to the resolutions of the International Astronomical Union at the Zürich Assembly in 1948, the Rome Assembly in 1952, and the Dublin Assembly in 1955; these changes are described in the Preface to the 1960 volume. This Office has co-operated with H.M. Nautical Almanac Office in the preparation of an *Explanatory Supplement* containing detailed explanations of all the ephemerides in the volume, and the methods of calculating them, together with auxiliary tables and other supplementary information.

The preparation of advance predictions of solar eclipses, begun in 1949 at the request of the International Astronomical Union, has been continued; see the report of Commission 13.

The research project on the motions of the principal planets undertaken in 1947 jointly by the Yale University Observatory, the Watson Scientific Computing Laboratory, and the U.S. Naval Observatory, with the support of the Office of Naval Research, has been continued. Since the preceding report, *Astronomical Papers of the American Ephemeris*, Vol. XVI, Part I, has been published, containing R. L. Duncombe's discussion of the meridian observations of Venus, 1750–1949, in which corrections are obtained to the elements of Venus and the Earth, to the secular variations, and to the mass of Mercury; his results remove the discrepancy between the theoretical and observed motions of the node of Venus. The relativity effect in the motion of the perihelion of Venus is detected; and a discrepancy between the theoretical and observed secular variation of the obliquity is confirmed. On the new general theory of Mars, see the report of Commission 7.

EDGAR W. WOOLARD

*H.M. Nautical Almanac Office, Royal Greenwich Observatory, Herstmonceux, England*

The routine work of the Office has been continued. The Office now is responsible for the publication of 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.

As from the edition for 1960, *The Astronomical Ephemeris* (which title replaces the former title of *The Nautical Almanac and Astronomical Ephemeris*) has been completely unified with *The American Ephemeris*. Although there has been no substantial change of content, many changes of detail, described in the preface to the edition for 1960, have been introduced. *The Nautical Almanac* and *The Air Almanac* were, of course, already unified with the U.S. editions of the same titles. All three publications are printed separately in the two countries 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 almanacs in this form.

The advance proofs of the first part of *The Astronomical Ephemeris* have been circulated to the offices of the national ephemerides and to other agencies concerned with the preparation of navigational and other almanacs. The only change that has been made is the substitution in 1965 of the tabulation of the E.T. of ephemeris transit of the Sun for the tabulation of the

equation of time; this has been done to prevent confusion with the traditional navigational definition of the equation of time as the difference between mean and apparent time.

The *Explanatory Supplement* (to *The Astronomical Ephemeris* and to *The American Ephemeris*), is now all in proof and will be published in the United Kingdom during 1961; this contains a detailed explanation, and numerical illustrations of the derivation, of all the tabulated quantities, together with much reference and tabular material of relevant interest; in particular it includes a complete list of the authorities for the ephemerides in *The Nautical Almanac* since 1767 and *The American Ephemeris* since 1855.

The nineteenth and last volume of *Apparent Places of Fundamental Stars* to be prepared and published by the Office was for the year 1959, published in 1958. The editions for 1960 onwards have been prepared and published by the Astronomisches Rechen-Institut in Heidelberg.

The third volume of *Planetary Co-ordinates for the Equinox* 1950·0, covering the years 1960–80, was published in May, 1958.

The occultation programme has been continued without modification, except that, as from 1960, predictions are no longer included in the ephemerides; arrangements have been made to publish them elsewhere.

A small electronic computer, the Hollerith Type 1201, has been installed in the Office and is being increasingly used for the calculation of ephemerides, as well as for the reduction and analysis of observations made in other departments of the Observatory. The availability of an electronic computing machine makes possible direct transformations of axes, as for example with the corrections for precession and nutation, without the necessity for approximate expansion in series. The computer is also being used for the extension of the Improved Lunar Ephemeris from 1972 onwards.

D. H. SADLER

*Astronomisches Rechen-Institut, Heidelberg, Germany*

*Fundamental catalogue.* The derivation of systematic corrections to the positions and proper motions of the FK 3 has been completed. The new Fundamental Catalogue FK 4 is being derived by the application of the individual corrections (already published for 1956–60) plus systematic corrections to FK 3. In spite of the fact that the publication of the FK 4 is to be expected in 1961 we will publish the individual corrections (FK 3R) to FK 3 for the years 1961 and 1962 for the observation of AGK 3.

Furthermore, the total corrections 'FK4 *minus* FK3' and the systematic corrections 'FK4 *minus* FK3R' will be published for a certain number of years.

*APFS and exchange of ephemerides.* The international volume *Apparent Places of Fundamental Stars* has been published by the Astronomisches Rechen-Institut from 1960 onwards. There is no essential change in content and presentation against earlier volumes. It should be mentioned that no separate list of mean places of fundamental stars will be printed before the completion of the FK 4. It is intended to publish separate lists after the completion of FK 4 at convenient intervals of years.

On request we have communicated apparent and mean places to the offices of the following almanacs in advance of publication: *Connaissance des Temps* (Paris), *Almanaque Nautico* (San Fernando), *Anuario do Observatorio de Sao Paulo* (Sao Paulo), *The Indian Ephemeris* (Alipore), *Nautisches Jahrbuch* (Hamburg), *Anuario del Observatorio Nacional de la Universidad de Chile* (Santiago de Chile), *Anuario, Observatorio Nacional* (Rio de Janeiro), *Almanaque Nautico y*

*Aeronautico* (Buenos Aires). Additional computations of apparent places have been carried out for those stars, which were observed with the Astrolabe of the Paris Observatory (1956–58) and with the PZT of the Neuchâtel Observatory (1957–59).

All calculations which so far have been done on an "Electronic Calculating Punch" IBM Type 626 will in future be carried out on the fast electronic computer "Siemens 2002" which will be installed in the Institute in 1961.

W. FRICKE

*Bureau des Longitudes, Paris, France*

*La Connaissance des Temps* continue à publier le catalogue des positions moyennes des étoiles du FK 3; elle publie également le tableau des parallaxes stellaires d'une valeur égale ou supérieure à 0·010.

Les éphémérides des 52 circompolaires figurant dans *Apparent Places of Fundamental Stars* sont calculées par nous. On y a utilisé les nouvelles formules de la nutation élaborées par E. W. Woolard. D'autre part, on a introduit les modifications relatives à l'aberration: on a substitué la longitude barycentrique du soleil à sa longitude géocentrique et tenu compte des perturbations lunaires et planétaires de la vitesse orbitale de la terre. Les formules ainsi modifiées de la nutation et des constantes $A,B$ de Bessel figurent dans notre éphéméride pour 1960. Celles relatives aux constantes $C,D$ seront insérées dans le volume *Connaissance des Temps* pour 1962.

Nous donnons toujours les éphémérides de 217 étoiles dont 10 sont circompolaires. Le nombre de décimales sera désormais le même que celui figurant dans APFS. A partir de 1962, nos tableaux des constantes stellaires $A,B,C,D,E;\ A',B'$, ainsi que $f,g,G,h,H,i;\ f',\ g',\ G'$ seront donnés avec plus de précision et sous une forme remaniée.

On fournit, de jour en jour, l'obliquité moyenne de l'écliptique et non plus l'obliquité vraie. Dorénavant les trois éléments publiés (obliquité moyenne, $\Omega$, $d\omega$) figureront avec une décimale de plus.

Maintenant les configurations des quatre anciens satellites de Jupiter auront la forme de courbes continues, présentation qui apparaît plus claire que celle adoptée jusqu'à présent sous forme de positions isolées.

Nos derniers volumes contiennent un tableau fournissant, pour un lieu de latitude donnée, l'angle horaire au lever et au coucher d'un astre dont on connaît la déclinaison.

En ce qui concerne les publications annuelles: *Ephémérides Nautiques* et *Ephémérides Aéronautiques* aucun changement appréciable n'est intervenu dans leur composition.

G. FAYET

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During the time under review, two volumes of the *Annuaire Astronomique de l'U.R.S.S.* for the years 1961 and 1962 have been published; they appeared in 1959 and 1960 respectively. Both volumes have been prepared in full accordance with the amendment of national ephemerides provided for by the recommendations of the IAU and introduced since 1960. Eclipses present an exception, as all the predictions are given in Ephemeris Time, without any extrapolated correction to pass to Universal Time.

As the *Berliner Astronomisches Jahrbuch* has been discontinued since 1960, and according to the recommendations of Commission 4 (Ephemerides), made at the tenth General Assembly

in Moscow in 1958, an ephemeris of the lunar crater Mösting A has been regularly published since 1961 in the *Annuaire Astronomique de l'U.R.S.S.* To maintain the continuity of this ephemeris, an ephemeris of the crater for 1960 has been given in an appendix to the volume for 1961.

The ephemerides of the Sun, Moon and planets are being published in full accordance with the first part of the *Astronomical Ephemeris.*

The *Nautical Almanac* and the *Air Almanac* have been published regularly, as before, the *Nautical Almanac* for 1961 having appeared in a new format: the ephemerides in the daily tables are given for each hour of U.T.

Other work has been performed besides: the computation of apparent places of 664 stars for the time service has been continued according to the programme of the IGY. Daily ephemerides including short-period terms of nutation have been computed for the years 1959, 1960 and 1961.

Research work has been done, connected with the calculation of planetary aberration (**1**).

Star altitude curves for northern latitudes 80°–90° have been published (**2**).

A collected volume of tables and nomograms has been composed and published for the computation of ephemerides and the discussion of observations of artificial satellites of the Earth (**3**).

Questions concerning the determination of orbital elements and methods for computing ephemerides of artificial satellites have been elaborated (**4, 5**).

Some parameters of the Earth's gravitational field have been deduced from observations of the second and third artificial satellites of the Earth, launched in U.S.S.R. (**6**).

D. K. KULIKOV

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*Nautical Almanac Unit, Regional Meteorological Centre,*
*India Meteorological Department, Calcutta, India*

The first issue of the *Indian Ephemeris and Nautical Almanac* relating to the year 1958 was

published in March 1957, and the volumes for the years 1959, 1960, 1961 appeared in 1958, 1959 and 1960 respectively. The volume for 1960 was revised in accordance with the recommendations made at the eighth General Assembly in 1952. The ephemerides of the Sun, Moon and planets are given in conformity with the first part of the *Astronomical Ephemeris* furnished in advance by the British Nautical Almanac Office. Mean places of 482 selected stars are given and apparent places of 68 stars and of *Polaris* are given in accordance with the *Apparent Places of Fundamental Stars* compiled by the Astronomisches Rechen-Institut of Germany. The elements of eclipses are received from the Nautical Almanac Office, U.S. Naval Observatory.

The following are some of the major items in respect of which computations are made in this Office and added to the Ephemeris:

*Sun:* Time of Ephemeris Transit. *Planets:* Apparent Geocentric Longitude and Latitude of planets. Apparent Right Ascension and Declination of Pluto along with the reduction to astrometric places are given. The rectangular co-ordinates of the barycentre of the solar system are being given from the issue for 1962. *Stars:* Besselian Day Numbers at 10-day intervals for $0^h$ Greenwich Sidereal Time and Longitude and Latitude of certain selected stars with their annual variations and proper motions are computed and published. *Eclipses and Occultations:* Circumstances and predictions of eclipses with reference to India are given in detail and elements of occultations of planets and bright stars are calculated and published. Heliacal rising and setting of planets (Mercury to Saturn) are calculated for the Central Station of India (Lat. 23° 11′N, Long. 82° 30′E) on the basis of certain adopted values of the arcs of visibility. Arrangement has been made to have the predicted dates verified by naked-eye observation at the Nizamiah Observatory, Hyderabad.

All data such as *tithi*, *nakshatra* etc., required for an Indian *Panchang* are calculated and given in the Indian Calendar portion of the publication.

In addition to the main publication, *Rashtriya Panchangs* in English, Sanskrit, Hindi and nine other regional languages giving all details of the Indian Calendar are published.

N. C. LAHIRI

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The following work has been done in the Hydrographic Division:

*Compilation and Publications: Japanese Ephemeris* for the years 1960–62; *Nautical Almanac* for the years 1959–61, *Abridged Nautical Almanac* for the years 1959–61. As from 1960 onwards, the *Japanese Ephemeris* is published in accordance with the recommendations of the IAU.

Y. TSUKAMOTO