

4. COMMISSION DES EPHEMERIDES

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MEMBRES: MM. Benitez †, R. Carrasco, Chazy †, Clemence, Cot, Eckert, Fayet, Gigizkij †, Gondolatsch, Hagihara, Kahrstedt, Kohl, Kopff, D. K. Kulikov, K. A. Kulikov, Mme McBain Sadler, MM. Planelles, Porter, Woolard, Yongolovich.

SURVEY OF PROGRESS

Introduction

Most of the work of preparing Ephemerides is concentrated in the ephemeris offices, and will be found described in the reports from the Directors of the national ephemerides which are included at the end of this report. The main portion of this report consists of a general survey of the progress made and the changes introduced as a result of the recommendations made at the last meeting of the commission in Rome in 1952. Emphasis is placed on those matters which need discussion by the commission, or which may affect international co-operation between the ephemeris offices. No attempt is made to include a complete bibliography of published papers, and detailed lists of papers of minor importance have been omitted from the reports of the Directors.

The Atkinson proposal

As authorized, the President conducted an enquiry among the members of Commissions 4 and 8 with a view to reaching agreement on the 'Atkinson proposal' (1). Although there was actually a majority in favour of the proposal, there was a substantial opposition which considered that the advantages were insufficient to warrant a fundamental change of procedure. Such a proposition can only be accepted by general agreement, and it was accordingly declared that the Atkinson proposal would *not* be adopted.

The improved lunar ephemeris

Several papers have been written on the amendment to the lunar ephemeris consequent upon the adoption of Recommendation no. 3 of the commission at its last meeting. The calculation of the longitude, latitude and horizontal parallax according to Recommendation no. 12 has been completed for the period 1952-71 by W. J. Eckert and his collaborators at the Watson Scientific Computing Laboratory. These values have been made available to H.M. Nautical Almanac Office for the calculation of the apparent ephemeris of the Moon at hourly intervals, and will be used as the basis of the lunar ephemeris in the *Nautical Almanac* as from 1960 January 0. In order that the improved lunar ephemeris should be available for precise work as soon as possible, a Joint Supplement to the *American Ephemeris* and the (British) *Nautical Almanac* has been prepared under the title *Improved Lunar Ephemeris 1952-59*. This publication, which will be given a wide distribution, contains the longitude, latitude and horizontal parallax at half-daily intervals, and the apparent right ascension and declination at hourly intervals; the opportunity has been taken to include, for the same period, the fundamental daily values of the nutation in longitude and obliquity, and of the aberrational day numbers *C* and *D*, calculated on the new basis (2). The volume also contains full descriptions of the construction of the lunar ephemeris (by W. J. Eckert and collaborators), of the comparison of the ephemeris with Brown's *Tables* (by E. W. Woolard) and of the methods used for the subtabulation to twelfths (by A. E. Carter) and for the calculation of the nutation (by G. A. Wilkins).

The ephemeris of Mars

G. M. Clemence has already published the first-order theory of Mars (3) and has completed the second-order theory. But it will necessarily be some years before it is possible

to complete the comparison with observation, the determination of definitive elements, and the calculation of tables or an ephemeris. It may not be possible to complete this in time for the theory to be introduced into the national ephemerides for 1960.

Ephemerides of the five outer planets

The co-ordinates of the five outer planets (Jupiter, Saturn, Uranus, Neptune and Pluto) given in *Astr. Pap., Wash., 12* do not contain fully the small perturbations by the four inner planets. G. M. Clemence has now calculated these as general perturbations and has supplied H.M. Nautical Almanac Office with corrections to the rectangular co-ordinates of Vol. 12 for the period 1960–80. The perturbations will be included in the geocentric ephemerides to be published in the *Nautical Almanac*.

The first part of the 'Nautical Almanac'

H.M. Nautical Almanac Office is responsible for the calculation of the fundamental ephemerides of the Sun, Moon and planets, and for their early circulation to the other ephemeris offices. A descriptive list of contents of the first part of the *Nautical Almanac*, amended in accordance with the recommendations of the Commission, has been circulated to the Directors of the national ephemerides; it has received general agreement.

Ephemeris time

Attention is drawn to an article by D. H. Sadler (4), in which the concept of an 'ephemeris meridian' is introduced. This concept makes it possible to develop a consistent system of hour angles, meridian passages, etc., without appeal to an extrapolated value of ΔT .

The International Committee of Weights and Measures has recently been concerned with the definition of the unit of time. The second was defined by Recommendation no. 7, but it seems more desirable to use the tropical year, instead of the sidereal year, in order to preserve a fixed relationship with the second. The suggested definition

The second is the fraction $1/31\ 556\ 925\ 975$ of the tropical year for 1900.0

has been referred to Commission 31 for confirmation, but Commission 4 will certainly need to consider it also.

International Fundamental Astronomical Ephemeris

The possibility has been examined, in consultation with the Directors of the national ephemerides, of introducing, under the auspices of the I.A.U., an international publication to contain the fundamental astronomical ephemerides to the fullest accuracy. The substance of the proposal is that the single international publication would make it unnecessary for each of the national ephemerides to reprint the fundamental ephemerides to full accuracy and would enable them to cater more directly for the practical astronomer. His requirements can probably be met well enough by, say, 50 pages instead of the present 250 pages. Each national ephemeris would be smaller and could perhaps include useful data at present excluded because of lack of space. There is much in favour of this proposal in principle, but there are some practical difficulties. The main difficulty is financial in that the 'International Fundamental Astronomical Ephemeris' would have to be given a wide free distribution and its small sales would certainly not repay the cost of printing; experience with *Apparent Places of Fundamental Stars* indicates also that it is still not easy for all astronomers to purchase books published in other countries. A few users would require to have two books, but this would be balanced by the majority for whom the modified national ephemerides would be adequate. A real difficulty is that the proposal requires the co-operation of all, or almost all, the national ephemerides and allows little flexibility or freedom of choice.

Although this proposal has met with some support, it has not received the full agreement that is necessary for its successful adoption.

There is fortunately a simple alternative which offers greater flexibility with little or no additional cost. Instead of the fundamental ephemerides being set in type for each national ephemeris separately, they can be photographically reproduced from 'reproduction proofs' specially prepared from the type set for the first part of the *Nautical Almanac*. Arrangements can be made for the supply of such reproduction proofs at a small charge; as little or as much can be reproduced as desired; it is a simple matter to replace the headings by corresponding ones in different languages before photography; no proof-reading will be required. In view of this possibility, consideration of the 'International Fundamental Astronomical Ephemeris' has been abandoned.

The conformity of the 'American Ephemeris' and the (British) 'Nautical Almanac'

Agreement has been reached between the Directors of the two almanacs for the unification of *The American Ephemeris and Nautical Almanac* and *The Nautical Almanac* as from the year 1960; the substance of the agreement is as follows:

(a) With the exception of a short introductory section containing title page, preface, lists of festivals, etc., the two almanacs will be identical. They will be published separately in the United States of America and in the United Kingdom and will maintain their separate identities and (subject to possible later reconsideration) titles. They will be printed by photolithography from reproduction proofs taken from type set partly in U.S.A. and partly in U.K.

(b) H.M. Nautical Almanac Office will continue to compile the first part of the almanac (about 270 pages); this will be set in type and reproduction proofs will be supplied to the U.S. Nautical Almanac Office.

(c) The Office of the *American Ephemeris* will compile the second part of the almanac (about 280 pages) from data which are partly computed there and partly received from other ephemeris offices; this part will be set in type and reproduction proofs will be supplied to H.M. Nautical Almanac Office.

(d) Reproduction proofs of the whole almanac, with the exception of the short introductory section, will be available to other ephemeris offices through H.M. Stationery Office, which will make a small charge for supply.

Although this 'conformity' has been facilitated by the use of a common language, it is hoped that other ephemeris offices will be able to make use of the considerable saving of composition and proof-reading made possible by reproduction by photolithography. This appears to offer the best opportunity for reducing the high cost of printing the national ephemerides, while preserving for each country its own ephemeris with its own language headings and with its own selection of material.

'Apparent Places of Fundamental Stars'

As from the year 1956 this international volume will be reproduced by photolithography from copy prepared on the card-controlled typewriter in H.M. Nautical Almanac Office. Only very minor changes in form, and none in content, will be necessary. All copies will be bound in cloth instead of in paper covers as at present.

Much concern has been expressed in previous years at the poor circulation of *Apparent Places of Fundamental Stars* and the difficulty of purchasing copies. The saving in printing costs due to the new method of production will mean a reduction in price and will also permit a larger free distribution; it is hoped that in these ways all requirements will be adequately met.

It is suggested that the pages containing the mean places of stars, most of the data on which are given on the pages containing the apparent places, should be omitted from the volume as from the year 1958.

A suggestion has also been made that apparent places of 10-day stars might, from some agreed date, be given continuously at intervals of ten transits.

Interchange of astronomical calculations

The availability of modern high-speed computing equipment, such as punched-card machines and electronic digital computing machines, has made the present distribution of astronomical calculations somewhat out of date. With such equipment it is now most efficient for the whole of one particular piece of work (such as the calculation of apparent places of stars) to be done in one, or at most two, offices. Some redistribution is desirable, and informal discussions are taking place between the Directors.

In this connexion consideration must be given to the possibility that, with the extension of the FK3 and with the requirements of the new faint-star catalogue, apparent places may be required for many more stars.

Occultations

The position of the Moon can now be observed with high accuracy with the dual-rate Moon cameras developed at the U.S. Naval Observatory. The importance of occultations will gradually diminish and it is doubtful if the present full programme of prediction, observation, reduction and discussion can be justified in the future. H.M. Nautical Almanac Office will continue with the programme as long as it is needed, but Commission 17 has been asked to consider the necessity for its continuance at its present level beyond 1960.

H.M. Nautical Almanac Office will, however, undertake the prediction of occultations of radio sources by the Moon, as suggested by Dr Link.

Navigational almanacs

It is of interest to note that there is an increasing tendency towards the Greenwich Hour Angle (G.H.A.) form of almanac for both sea and air navigation. Most almanacs, with the Japanese *Nautical Almanac* and *Abridged Nautical Almanac* as the outstanding exceptions, now tabulate G.H.A. and Dec. directly at various intervals. Many almanacs for use at sea follow the style of the *American Nautical Almanac*, in some cases actually reproducing the data photographically; the Italian *Effemeridi Nautiche* changed to this form in 1954. One or two others follow the British *Abridged Nautical Almanac*, which is, however, identical in principle and content, though not in arrangement, with the *American Nautical Almanac*; the French *Ephémérides Nautiques* will change in 1956 to a similar form. The G.H.A. form of air almanac is now almost universally used; the French *Ephémérides Aéronautiques*, already in this form, will be changed in 1955 to make use of the unified *Air Almanac* produced jointly by the U.S.A. and the U.K.

MATTERS FOR DISCUSSION IN DUBLIN

The following matters and proposals need to be discussed at the meetings of Commission 4:

1. The definition of the (ephemeris) second.
2. The proposal to omit the pages of mean places of stars from the international volume of *Apparent Places of Fundamental Stars* as from 1958.
3. The suggestion to tabulate the apparent places of 10-day stars continuously at intervals of ten transits, as from some agreed date.
4. The possibility of increasing the number of stars for which apparent places are calculated.
5. The redistribution of astronomical calculations.
6. That as from 1960 the orbit of Jupiter V used in the national ephemerides should be that of van Woerkom⁽⁵⁾.
7. That as from 1960 the period of rotation of Mars used in the national ephemerides should be that of Ashbrook⁽⁶⁾. (Proposals (6) and (7) have been made by G. M. Clemence.)

D. H. SADLER
President of the Commission

REFERENCES

- (1) *Trans. I.A.U.* **8**, 92, 1954.
- (2) *Trans. I.A.U.* **8**, 90, 1954.
- (3) G. M. Clemence, *Astr. Pap., Wash.*, **11**, part II, 1949.
- (4) D. H. Sadler, *Occasional Notes, R.A.S.*, no. 17, 1954.
- (5) A. J. J. van Woerkom, *Astr. Pap., Wash.*, **13**, part I, 1950.
- (6) Joseph Ashbrook, *Astr. J.* **58**, 145, 1953.

APPENDIX

REPORTS OF THE DIRECTORS OF THE NATIONAL EPHEMERIDES

Instituto y Observatorio de Marina, San Fernando (Cádiz), Spain

The contribution to *Apparent Places of Fundamental Stars*, of the apparent places of 396 10-day stars, has been continued. The *Almanaque Náutico*, *Almanaque Náutico para uso de los Navegantes* and *Almanaque Aeronáutico* have been published regularly, with only minor modifications.

W. BENITEZ

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The *American Ephemeris*, the *American Nautical Almanac*, and the unified *Air Almanac* have been published regularly without substantial changes.

The apparent places of 162 10-day stars have been supplied annually for the volume *Apparent Places of Fundamental Stars*.

The work on the motions of the principal planets undertaken in 1947 jointly by the Yale University Observatory, the Watson Scientific Computing Laboratory, and this Office has continued with the support of the Office of Naval Research. The general theory of the motion of Mars, mentioned in the preceding report, is now complete; before calculating the new ephemeris it remains to obtain suitable elements of the orbit by comparing the new theory with observations. Since the preceding report, *Astr. Pap., Wash.*, Vol. **12**, Vol. **13**, parts I, II, III, IV, V, Vol. **14**, and Vol. **15**, parts I and II have appeared. These contain precise co-ordinates of Jupiter, Saturn, Uranus, Neptune and Pluto, at 40-day intervals from 1653 to 2060, by Eckert, Brouwer and Clemence; a study of the motion of Jupiter V, 1842–1949, by A. J. J. van Woerkom; a new calculation of the secular variations of the orbital elements of the principal planets, by Brouwer and van Woerkom; a catalogue of the positions and proper motions of 5268 standard stars, based on the normal system N30, by H. R. Morgan; the co-ordinates of the centre of mass of the Sun and the five outer planets, 1800–2060, by Clemence; general perturbations of the five outer planets by the four inner ones by Clemence; precise co-ordinates of the Sun and of the centre of mass of the Earth and Moon at 4-day intervals from 1800 to 2000, by Paul Herget; a new general theory of the rotation of the Earth around its centre of mass, by Edgar W. Woolard; and a new determination of the mass of Saturn from its action on Jupiter 1884–1948, by Hans G. Hertz. Other work mentioned in the preceding report is still in progress or being prepared for publication.

G. M. CLEMENCE

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L'Annuaire Astronomique de l'U.R.S.S. has been published annually; the volume for the year 1956 appeared in March 1953, and that for 1957 in March 1954. The almanac for the year 1958 is ready for printing. The following changes have occurred during this period: beginning with 1955 the equatorial co-ordinates of the Moon are given for every hour instead of every 12 hours; beginning with 1957 apparent places of 64 additional stars are given, to meet the requirements of geodesists. Thus the almanac now includes mean places of 730 stars and apparent places of 673 stars.