4. COMMISSION DES EPHEMERIDES

PRÉSIDENT: M. G. FAYET, *Bureau des Longitudes, 3 Rue Mazarine, Paris (6e).*

VICE-PRÉSIDENT: M. D. H. SADLER.

MEMBRES: MM. Benitez, Clemence, Gigizkij, Hagihara, Jeffreys, Kahrstedt, Kopff, D. K. Kulikov, K. A. Kulikov, Yongolovich.

SOUS-COMMISSION DES CONSTANTES ASTRONOMIQUES

PRÉSIDENT: M. BROUWER.

MEMBRES. MM. Clemence, Danjon, Idelson†, Jeffreys, K. A. Kulikov, Spencer Jones, Lambert, Oort, Subbotin.

REPORT OF THE OFFICE OF THE 'AMERICAN EPHEMERIS' TO COMMISSION 4 OF THE INTERNATIONAL ASTRONOMICAL UNION

The following changes have occurred in the *American Ephemeris* and *Nautical Almanac*, in addition to those mentioned in the 1948 report. An astrometric ephemeris of Pluto, referred to the mean equinox and equator 1950.0, is given beginning with 1950. The astrometric ephemeris is obtained by applying the planetary aberration to a geometric ephemeris and then subtracting the fixed-star aberration, calculated by the conventional formula which neglects the portion depending on the longitude of the Earth's perihelion. The astrometric ephemeris therefore is rigorously comparable with observations that are referred to catalogue mean places of stars in the neighbourhood, it being only necessary to correct the observations for geocentric parallax. The astrometric ephemeris is not to be confused with the so-called astrographic ephemeris, heretofore used by some astronomers, from which it differs by the small elliptic portion of the annual aberration. Beginning with 1951 are given tables of interpolation coefficients, specially designed to facilitate interpolation of the solar co-ordinates. The first part of the section 'On the Arrangement and Use of the American Ephemeris' has been rewritten in order to define rigorously the basis of the ephemerides.

Both the apparent and the astrometric ephemerides of Ceres, Pallas, Juno, and Vesta are given beginning with 1952, thus catering for both meridian observations and photographic observations. The ephemerides for 1950 and 1951 have been published in *U.S. Naval Observatory Circulars*, Nos. 5, 7, 18 and 20.

Beginning with 1953 the designation Greenwich Civil Time will be dropped, and the designation Universal Time will be exclusively used to denote mean solar time reckoned from midnight of the Greenwich meridian, in accordance with Resolution 1 of Commission 4 at the General Assembly of 1948. The designation Universal Time will not, however, be introduced in purely navigational publications.

The American Air Almanac has been published in three volumes a year without change in form or method of preparation.

The American Nautical Almanac for 1950 was completely revised, after full consultation with users, and with the (British) Nautical Almanac Office, which at the same time was planning the revision of the *Abridged Nautical Almanac*. In consequence the two almanacs are almost identical in principle, although differing slightly in detail. In the *American Nautical Almanac* all of the fundamental data necessary for celestial navigation appear for three days on two facing pages. The Greenwich hour angle and declination of the Sun, Moon, and four planets are given at hourly intervals, and the sidereal hour angles and declinations of 57 stars are given once for the three days. Data for sunrise, sunset, and twilight are given for every third day, and moonrise and moonset for every day, from latitude 70 N. (72 from 1953) to 60 S. The altitude corrections have been simplified, and special interpolation tables are provided, so that no interpolation as such is needed for any navigational data. The sidereal hour angle and declination for 172 stars are given at monthly intervals from 1953. The almanac is prepared by the method used for the

American Air Almanac, described in the 1948 report, which ensures improved typographical accuracy.

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

For the volume of minor-planet ephemerides, published annually under the auspices of the Union from 1947, copy suitable for photographic reproduction has been prepared on the card-operated typewriter, from cards furnished by the minor planet centre at the Cincinnati Observatory.

At the request of the president of Commission 13 the tracks of total solar eclipses to the end of 1960 have been calculated, and published in the *U.S. Naval Observatory Circulars*.

The Office of Naval Research has continued to support the work undertaken in 1947 on the motions of the principal planets by the Yale University Observatory, the Watson Scientific Computing Laboratory, and this Office. The general first-order perturbations of Mars have been calculated by Hansen's method, and published in *Astronomical Papers of the American Ephemeris*, Vol. **11**, part 2. significant corrections to Newcomb's theory are indicated, and the calculation of the perturbations of the second order, neglected by Newcomb, is in progress. The co-ordinates of Jupiter, Saturn, Uranus, Neptune, and Pluto, at 40-day intervals from 1653 to 2060, have been obtained with very high precision by simultaneous numerical integration with the Selective Sequence Electronic Calculator of the International Business Machines Corporation, and will shortly be published in *Astr. Papers*, Vol. **12**; appreciable errors increasing with time are indicated in Hill's and Newcomb's theories of the first four of these planets. Discussions of meridian observations of Venus and Jupiter are in progress.

A comprehensive revision of the orbit of Pluto, using all available observations, has been undertaken with the co-operation of the Lowell Observatory and the Lick Observatory. The positions of Pluto on the extensive series of plates taken at the Lowell Observatory in every opposition of Pluto since its discovery are being transferred to larger plates taken along the path of Pluto with the 20-inch astrograph at the Lick Observatory; these in turn are being referred to brighter stars on plates taken at the Yale Observatory, which will be reduced with a special catalogue of bright stars compiled here, and already published as *Astr. Papers*, Vol. **11**, part 3. Other shorter series of observations of Pluto obtained elsewhere will also be worked in.

Ephemerides of the Sun and Venus for the whole of the nineteenth and twentieth centuries are being extracted from Newcomb's Tables at the Cincinnati Observatory, to the full accuracy that the tables are capable of giving.

Other work mentioned in the 1948 report is still in progress.

Details of further work on the motions of the principal planets will be found in the reports of Commissions 7 and 20.

The Director of this Office participated in the Paris Conference on the Fundamental Constants of Astronomy in March 1950.

G. M. CLEMENCE

PROPOSALS BY G. M. CLEMENCE FOR DISCUSSION AT THE MEETING OF COMMISSION 4

1. If Resolution 6 of the Paris Conference of March 1950 is adopted, it is proposed that the pages of the national ephemerides now containing the notation *Universal Time*, or the equivalent in other languages, should be altered to read *Ephemeris Time*, or the equivalent in other languages, or any other designation that may be substituted officially for Ephemeris Time, excepting the sections on eclipses and occulations, and any other sections where the actual Universal Time is predicted in advance.

This change would not imply any change in the basis of the ephemerides, but would simply recognize a fact already existing, namely, that the variable measure of Universal Time is not the measure which actually constitutes the basis of the ephemerides. To continue the use of the term Universal Time in two different senses is illogical, and

productive of confusion. The change naturally would not be made in purely navigational publications, where the ephemerides are altered from time to time, to bring them on the basis of the variable Universal Time.

Once the question of notation has been agreed, a table of reductions from Universal Time to Ephemeris Time (or other adopted designation), calculated by the formula of Resolution 6 of the Paris Conference, will be published annually in the *American Ephemeris*.

2. The inclusion of the short-period terms of the nutation in the apparent places of stars and their omission from the apparent places of the Sun, Moon, and planets produces errors in the comparison of observations with the ephemerides, which it is not practicable to remove subsequently. It is proposed that the apparent places of the Sun, Moon, and planets should include the short-period terms of the nutation, the date of the change to be decided by the (British) Nautical Almanac Office.

3. If the (British) Nautical Almanac Office should conclude that it is practicable to comply with Resolution 2 of the Paris Conference by admitting gravitational inconsistencies into the lunar ephemeris not exceeding a few hundredths of a second of arc, then it is proposed that the lunar ephemeris should be amended as recommended, since it is known that similar inconsistencies of somewhat larger magnitude are already present in Brown's Tables. If, on the other hand, it would be practically necessary to admit gravitational inconsistencies as large as a tenth of a second of arc, then it is proposed that no amendment to the lunar ephemeris should be made. The lunar ephemeris is now hardly accurate enough to meet the requirements of modern observations, and no appreciable deterioration in accuracy should be permitted.

Report of the (British) Nautical Almanac Office to Commission 4 of the International Astronomical Union

The *Nautical Almanac* has been published without any change in the basis of the fundamental ephemerides. As from the year 1950 an astrometric ephemeris of Pluto has been included, and both apparent and astrometric ephemerides of the four principal minor planets—Ceres, Pallas, Juno and Vesta—are being given in the *Almanac* for 1952. In both cases these ephemerides are based on heliocentric rectangular co-ordinates supplied by the office of the *American Ephemeris*; the ephemerides of the minor planets for 1950 and 1951 have been published in *U.S. Naval Observatory Circulars*, Nos. 5, 7, 18 and 20.

In conformity with the resolution adopted by the General Assembly at the 1948 (Zürich) meeting, all references to Greenwich Mean Time (G.M.T.) in the Almanac have been replaced, as from 1952, by 'Universal Time (U.T.) or Greenwich Mean Time (G.M.T.)', the use of G.M.T. will be discontinued in the Almanac in a few years' time. G.M.T. continues to be used in purely navigational publications.

As from 1954 (the first year in which the alteration could be made) the accepted 10-day dates, to be used for ephemerides of comets and minor planets, will be indicated by printing in heavy type the relevant entries in the ephemerides of the Sun's equatorial rectangular co-ordinates.

Two further changes occur in the Almanac for 1952. With the publication as from 1951 of the *Star Almanac for Land Surveyors*, there is no longer any necessity for the retention of apparent places of stars in the *Nautical Almanac* and these have therefore been omitted, the opportunity has been taken, however, of extending the list of mean places of stars to include the 1078 brighter than magnitude 4·75. The elements for the prediction of lunar occultations have been omitted, since the predictions themselves are made available by the Office; the apparent places of occulted stars, required in the reduction of occultations, are still being included.

Little progress has been possible with the preparation of the separate *Supplement*.

The volumes of *Apparent Places of Fundamental Stars* have been published regularly with little change of content. The redistribution of the calculations for the 10-day stars,

agreed informally between the Directors of the national ephemerides at the Zürich meeting, has worked entirely satisfactorily; all calculations have been received before their due dates. A Russian language translation of the Introduction has been introduced in the volume for 1951.

In consultation with Dr Brouwer a list is being drawn up of all stars in the volume for which it is recommended that corrections for annual parallax should be given, this list, with explanatory notes, will be circulated to the Directors before the meeting in Leningrad. It will be proposed that the introduction of the corrections be deferred until 1956, when it is hoped to base the ephemerides on the new Day Numbers agreed to at the last meeting. Full details of the proposed procedure in regard to the aberrational day numbers *C* and *D* are in progress of publication in a paper in *Monthly Notices, R.A.S.*

The *Abridged Nautical Almanac* has been completely revised and will be issued, in its new form, early in 1951 for the year 1952. The revised *Almanac* tabulates the Greenwich Hour Angle (G.H.A.) and declination (Dec.) at hourly intervals, for the Sun, Moon and planets, for the stars, the G.H.A. is formed by the addition of G.H.A. Aries (sidereal time in arc), which is tabulated for each hour, and the Sidereal Hour Angle (S.H.A.) of the star. The S.H.A. and Dec. for each of 172 stars are given at monthly intervals. The *Almanac*, in its revised form, is almost identical in principle with the *American Nautical Almanac* and the Spanish *Almanaque Nautico para uso de los Navegantes*. The *Air Almanac* has been published regularly without change of form.

The *Star Almanac for Land Surveyors*, referred to in the Report presented in 1948, was introduced for the year 1951. Its main feature is the inclusion, to an accuracy of $0^{s}{\cdot}1$ and $1''$, of the apparent places of 650 stars. It is hoped that it will fill the gap that has long existed between the requirements of the navigator and those of the astronomer.

Active work is in hand on the preparation of the third volume of *Planetary Co-ordinates for the Equinox* 1950.0, designed to cover the twenty years 1960–80. It is probable that the data for the five outer planets will be based on the numerical integrations of the motions of these bodies being done in the United States. Publication should take place before 1956.

The occultation programme continues to demand a large proportion of the time of the staff; a report is being made to Commission 17.

Mr Sadler attended the Paris Conference on the 'Fundamental Constants of Astronomy' in March, 1950. As requested by that Conference, an examination has been made of the practicability of carrying out Resolution No. 2 concerning the change in the basis of the ephemeris of the Moon. The Nautical Almanac Office concludes that the recommended change in the lunar ephemeris can be carried out without introducing significant gravitational inconsistencies. If the above recommendation be approved, it will be possible to introduce the change in the lunar ephemeris as from January 1, 1961.

Suggested Matters for Discussion at the New Meeting of Commission 4

1. The Resolutions of the Paris Conference on the 'Fundamental Constants of Astronomy' in so far as they affect the National Ephemerides.

Reference is made in the Report of the Nautical Almanac Office to the implication of Resolution 2, concerning the change in the lunar ephemeris. Other matters, such as the responsibility for and notation to be used for the correction to Ephemeris Time to give Universal Time should be discussed.

2. Day Numbers. Confirmation is required as to the practicability of introducing the revised Day Numbers (particularly in so far as they depend on the recalculation of the nutation now in progress in the Office of the *American Ephemeris*) into the apparent places of stars in 1956. It is clearly impossible to use the new values of the nutation in the ephemerides of the Sun, Moon and planets by this date; 1961 is suggested as a convenient date for their introduction.

3. Short-period terms of nutation. The present accuracy of time-keeping is such as

to require the inclusion of short-period terms of nutation in the reduction of all star observations; corrections must therefore be applied to the ephemerides of 10-day stars. It is proposed that the inclusion of the short-period terms of nutation in the daily ephemerides of the Sun, Moon and planets should be seriously considered as from 1961 January 1.

D. H. SADLER

INSTITUTO Y OBSERVATORIO DE MARINA, SAN FERNANDO, ESPAGNE

La collaboration convenue au volume international *Apparent Places of Fundamental Stars*, c'est-à-dire le calcul des positions apparentes de 396 étoiles, de 10 en 10 jours, a été poursuivie régulièrement.

Almanaque nautico. Peu de modifications ont été apportées à cette publication, qui a utilisé, en partie, les résultats qui lui ont été communiqués par les autres Instituts de calcul. Elle donne, en particulier, l'éphéméride de Pluton.

Almanaque Nautico para uso de los Navegantes. Sous le titre 'Extracto del Almanaque Nautico para uso de los Navegantes', on a publié, depuis 1943, cet extrait destiné aux marins. Il a subi diverses modifications, l'édition pour 1951 a été rédigée conformément au plan adopté par *The American Nautical Almanac* et présenté par M. Clemence à l'Assemblée Générale de Zürich, en 1948.

Almanaque Aeronautico. Publication effectuée, depuis 1944, à la demande du Ministère de l'Air. Actuellement elle paraît en fascicules, portant sur 4 mois chacun, dont la disposition est semblable à celle de *The Air Almanac*.

W. BENITEZ

ASTRONOMISCHES RECHEN-INSTITUT À HEIDELBERG

RAPPORT À LA COMMISSION 4, POUR LA PÉRIODE 1945–50

En juillet 1945, l'Astronomisches Rechen-Institut a repris ses travaux à Heidelberg. Les collaborateurs sont sensiblement les mêmes qu'à Berlin-Dahlem. La direction des travaux pour le *Jahrbuch* est confiée au Dr Fr. Gondolatsch.

En ce qui concerne les tâches internationales et, en particulier, la contribution allemande à 'Apparent Star Places', les travaux se poursuivent sans changement. Les positions moyennes, pour le début de l'année, de toutes les étoiles du FK3 sont prêtes pour la période 1950–75. Les éphémérides de 10 en 10 jours des positions apparentes de 560 étoiles continuent à être calculées régulièrement et, de même, les éphémérides de jour en jour pour 20 étoiles circompolaires. A cela, s'ajoutent, pour chaque année, les données relatives à l'anneau et aux satellites de Saturne.

Les travaux préparatoires au calcul des éphémérides de 10 en 10 jours de 560 étoiles pour la période 1956–75 ont été commencés.

Diverses modifications ont été apportées à la publication des *Jahrbücher*. Pour les années 1947 et 1948, l'Astronomisches Rechen-Institut in Heidelberg a encore publié un *Astronomisches Jahrbuch* sous sa forme ancienne. L'année 1949 a vu paraître un *Astronomisch-Geodätisches Jahrbuch* dont les quatre années, de 1949 a 1952, sont actuellement publiées. Cet ouvrage contient, outre les calculs propres de l'Institut, certaines données du Nautical Almanac Office (Londres), du Bureau des Longitudes (Paris), et du Nautical Almanac (U.S. Naval Observatory. Washington). L'année 1951 contient en outre une refonte des *Grundbegriffe der Sphärischen Astronomie* (également publiés à part aux éditions G. Braun, Karlsruhe).

L'*Astronomisch-Geodätisches Jahrbuch*, qui résulte de nombreux échanges de vue avec les géodésiens, doit être un annuaire utile pour la pratique et pour l'enseignement de la géodésie. Il contient, pour les quatre premières années, principalement: les éphémérides de 10 en 10 jours des positions apparentes abrégées de 232 étoiles du FK3 choisies pour

l'hémisphère Nord; les éphémérides, de jour en jour, de 10 étoiles circompolaires, les éphémérides, de 2 heures en 2 heures, de l'angle horaire du point vernal et des coordonnées du soleil, E et Déclinaison; enfin, une série de tables auxiliaires indispensables aux géodésiens.

L'*Astronomisch-Geodätisches Jahrbuch* n'a pas encore pris sa forme définitive. Dans les premières années après la guerre, on ne savait pas dans quelle mesure il serait possible de se procurer des annuaires occidentaux. D'où la nécessité de faire figurer dans le *Jahrbuch* publié à Heidelberg toutes les données nécessaires aux astronomes. Mais une nouvelle refonte de l'*Astronomisch-Geodätisches Jahrbuch* tenant compte encore davantage des besoins des géodésiens, est en preparation.

Les positions moyennes et apparentes calculées à Heidelberg pour chaque année, sont mises à la disposition du *Berliner Astronomisches Jahrbuch*, où elles sont aussi imprimées en totalité. Y sont également publiées les données concernant l'anneau et les satellites de Saturne, obtenues à Heidelberg. Depuis l'année 1949, l'Astronomisches Rechen-Institut in Heidelberg figure comme co-éditeur du *Berliner Astronomisches Jahrbuch*.

Disons encore qu'a commencé à paraître avec l'année 1947. à l'usage des éditeurs de Calendriers, un fascicule intitulé 'Astronomische Grundlagen für den Kalender 1947' Cette publication s'est poursuivie les années suivantes.

A. KOPFF

RAPPORT TCHÉCOSLOVAQUE À LA COMMISSION NO. 4 DE L'U.A.I.

Conformément à la résolution de la Commission des éphémérides prise à Zürich, le *Supplément international* de l'*Annuaire astronomique tchécoslovaque* paraît regulièrement depuis 1949 et il est distribué à plus de 400 observatoires et instituts du monde entier. Le *Supplément* calculé par les soins de l'Observatoire National de Prague (depuis 1951 Institut Central d'Astronomie) contient:

(*a*) Positions relatives de la Lune et de l'antisoleil en coordonnées équatoriales et polaires, données de 10 en 10 minutes de temps, pour chaque éclipse de Lune.

(*b*) Positions du terminateur de l'ombre terrestre.

(*c*) Eléments pour le calcul d'occultations des étoiles faibles pendant ces éclipses.

(*d*) Occultations d'étoiles brillantes d'après le *Nautical Almanac*, pour Prague et pour toute l'année.

(*e*) Positions journalières de l'apex terrestre.

D. F. LINK

TOKYO ASTRONOMICAL OBSERVATORY—MITAKA, TOKYO, JAPAN

Until 1947, we had been prevented from the international exchange agreements by emergencies caused by the Second World War. For the sake of our astronomical observations in Japan, we had computed the ephemerides of 500 stars of the FK3, the Sun, Moon, planets and the prediction of occultations visible at the Tokyo Astronomical Observatory.

After 1947, we have carried out various computations, necessary for our astronomical researches in Japan, in co-operation with the Astronomy Research Committee in the Science Council of Japan.

A. *Published Works of the Tokyo Astronomical Observatory*

1. The Corpuscular Eclipse of May 8–9, 1948 (U.T.). (Y Sato, *Tokyo Astronomical Bulletin*, Ser. 2, no. 9, 1948.)
2. Heliocentric Co-ordinates of Jupiter for the Years 1960–2060 referred to the Equinox 2000.0. (Y Sato, *Annals of the Tokyo Astronomical Observatory*, Ser. 2, **2**, 2, 1949.)
3. Heliocentric Co-ordinates of Saturn for the Years 1960–2060 referred to the Equinox 2000.0. (Y Sato, *Annals of the Tokyo Astronomical Observatory*, Ser. 2, **2**, 4, 1950.)

4. A Total Eclipse of the Sun, June 20, 1955. (Y. Sato, S. Habara and T. Takasaki, *Tokyo Astronomical Bulletin*, Ser. 2, no. 22, 1950.)
5. Heliocentric Co-ordinates of Jupiter for the Years 2060–2148 referred to the Equinox 2000.0. (Y. Sato, *Annals of the Tokyo Astronomical Observatory*, Ser. 2, **3**, 3, 1951.)
6. Theory of the Rotation of the Earth having three unequal Principal Moments of Inertia. (N. Sekiguchi, *Tokyo Astronomical Observatory Reprints*, No. 47, 1949.)
7. A New Numerical Expression of Nutation Terms. (N. Sekiguchi, *Tokyo Astronomical Observatory Reprints*, No. 53, 1950.)

Nos. 1 and 4 are the results computed by the request of the Sub-Committee of the Solar Eclipse of Japan.

Nos. 2, 3 and 5 are the results computed at the request of the Astronomy Research Committee. The need for computing the heliocentric co-ordinates of these two planets is for providing the investigators of the libration of the characteristic asteroids, especially. of Hilda and Thule, with the necessary co-ordinates of Jupiter and Saturn. As the period of libration is over several hundred years, the extension of the 'Planetary Co-ordinates' prepared by Dr Comrie is necessary. At the same time the results of computation will be useful to the perturbation computers of asteroids and comets. The report of No. 5 is in the course of printing. A copy of the hand-written report was sent to Dr Sadler, Superintendent of H.M. Nautical Almanac Office, on July 25, 1950.

In No. 6, the amount of $B-A$, the difference of the principal moments of inertia in the plane of the equator of the Earth is taken from Schweyder's value in *A.N.* **203**, 1917. The expressions of the precession and the nutation, the motion of the Earth's pole and the velocity of the rotation are computed. It is found that the effects of the difference of A and B are too small to be detected by observations, inadequacy of the previous method, hitherto used for discussing the expressions of the precession and the nutation, is remarked.

In No. 7, the nutation terms are calculated again with the theory developed in the report of No. 6. Then, the effects are studied on the declinations of stars in comparison with the results of the latitude observations of the International Latitude Service.

B. *Published Works of the Maritime Safety Agency*

1. *Japanese Ephemeris for* 1949
2. *Nautical Almanac for* 1949
3. *Abridged Nautical Almanac for* 1949
4. *Altitude and Azimuth Almanac for* 1949

} Published in the year 1948.

5. *Japanese Ephemeris for* 1950 *and for* 1951
6. *Nautical Almanac for* 1950
7. *Abridged Nautical Almanac for* 1950
8. *Altitude and Azimuth Almanac for* 1950

} Published in the year 1949.

9. *Japanese Ephemeris for* 1952
10. *Nautical Almanac for* 1951
11. *Abridged Nautical Almanac for* 1951
12. *Altitude and Azimuth Almanac for* 1951
13. *Supplementary Nautical Almanac for* 1951

} Published in the year 1950.

YUSO SATO,
Chief of Computing Section
Y HAGIHARA,
Director of the Tokyo Astronomical Observatory

Bureau des Longitudes (Paris)

Dans le but de regagner peu à peu le retard considérable qui existe encore dans l'époque de sa publication, la *Connaissance des Temps* a dû, provisoirement et pour une période qui, je l'espère, sera d'une courte durée, restreindre l'importance de sa contribution au volume international *Apparent Places of Fundamental Stars*, et limiter celle-ci au calcul des positions apparentes quotidiennes de 32 étoiles circompolaires. Ceci nous a permis de diminuer progressivement notre retard d'une façon très appréciable. Le volume pour 1951 a paru en juillet 1950 et nous comptons que celui concernant 1952 sera distribué dès mai 1951.

Comme par le passé, nous avons assumé la tâche de calculer et publier, d'après les Tables de R. A. Sampson, les éphémérides détaillées relatives aux quatre premiers satellites de Jupiter.

On a ajouté quelques renseignements complémentaires concernant les éclipses et l'on a décidé de fournir désormais les éléments des éclipses de Lune par la pénombre.

La publication annuelle du volume des *Ephémérides Aéronautiques* a été assurée régulièrement. Depuis 1947 l'ouvrage est édité en fascicules et, à le fin de chacun de ceux-ci, se trouvent des tables dont certaines figuraient auparavant dans l'annexe. Depuis 1948, voici les principales modifications qui ont été apportées à cette publication:

1° Depuis 1949, les diagrammes intitulés 'Positions des astres', qui représentaient approximativement, en hauteur, et en azimut, la Lune, les planètes et les principales étoiles, aux diverses heures et pour les latitudes $-10°$, $-30°$; $+10°$, $+30°$, $+50°$ et $+70°$, ont été supprimés et remplacés par deux cartes célestes (une pour chaque hémisphère) contenant les 72 étoiles de la liste qui figure à la seconde page de la couverture de chaque fascicule et un certain nombre d'autres étoiles destinées à faciliter le repérage des précédentes.

2° Dans le fascicule de juillet-août 1949, on a introduit, à title d'essai, un nomogramme permettant d'obtenir les heures du lever et du coucher du Soleil, en fonction de la latitude du point d'observation et de la déclinaison de l'astre.

Dès 1948, l'organisation d'un Colloque International sur les Constantes Fondamentales de l'Astronomie avait été envisagée par notre Centre National de la Recherche Scientifique. Soumise aux astronomes intéressés, lors de l'Assemblée Générale de l'Union Astronomique Internationale, tenue à Zürich, au mois d'août de la même année, cette décision avait été favorablement accueillie.

Organisé, à l'Observatoire de Paris, par M. Danjon, Directeur de cet Etablissement, le colloque eut lieu, sous la Présidence de notre Collègue, du 27 mars au 1er avril 1950.

Dans une publication spéciale,* se trouvent réunis:

1°. Les rapports préliminaires établis par MM. Brouwer, Clemence, Jeffreys, Kulikov, Morgan, Nemiro, Oort, Stoyko, Zverev.

2°. Le texte de la Conférence prononcée à la séance d'ouverture par Sir Harold Spencer Jones.

3°. Les procès-verbaux des séances de travail établis par M. Sadler, et traduits par M. Fayet.

4°. Le texte des recommandations formulées par la Conférence au cours de la séance de cloture, et qui seront soumises à l'agrément de l'Union Astronomique Internationale.

G. Fayet

Sous-Commission des Constantes Astronomiques

The report of this Sub-Commission may be limited to a reference to the conference on the Fundamental Constants of Astronomy, organized by the Centre National de la Recherche Scientifique, and held in Paris, March 27 to April 1, 1950.

* *Colloques internationaux du Centre National de la Recherche Scientifique*—XXV: *Constantes Fondamentales de l'Astronomie. Paris, 27 mars–1er avril* 1950.

An extensive report of this conference appeared in *Bulletin Astronomique*, **15**, fasc. III, IV, 1950, and was published separately as *Colloques Internationaux du Centre National de la Recherche Scientifique*, **25**, 1950.

The resolutions of this conference are submitted as recommendations to the International Astronomical Union.

Recommendations

1. Concerning the system of astronomical constants, the Conference recommends that no change be made in the conventionally adopted value of any constant.

2. In order to bring the lunar ephemeris into accordance with the solar ephemeris the Conference recommends that Brown's Tables of the Motion of the Moon should be amended by removing the empirical term and by applying to the mean longitude the correction:

$$-8''\cdot72-26''\cdot75T-11''\cdot22T^2,$$

where T is measured in Julian centuries from 1900 January 0 Greenwich Mean Noon. H.M. Nautical Almanac Office will report on the practical implications of this recommendation.

3. The Conference recommends that no change be introduced in the current tables of the Sun, Mercury and Venus, or in the national ephemerides of these bodies.

4. The Conference recommends that the ephemeris of Mars in the national ephemerides should be based, as soon as practicable, on the new theory now being constructed at the U.S. Naval Observatory.

5. The Conference recommends that the positions of the five outer planets (Jupiter, Saturn, Uranus, Neptune, and Pluto) given in the national ephemerides should be based as soon as possible on the motion of these bodies obtained by the numerical integrations now in progress in the U.S.A.

6. The Conference recommends that, in all cases where the mean solar second is unsatisfactory as a unit of time by reason of its variability, the unit adopted should be the sidereal year at 1900·0: that the time reckoned in these units be designated 'Ephemeris Time'; that the change of mean solar time to ephemeris time be accomplished by the following correction:

$$\Delta t=+24^s\cdot349+72^s\cdot3165T+29^s\cdot949T^2+1\cdot821B,$$

where T is reckoned in Julian centuries from 1900 January 0 Greenwich Mean Noon and B has the meaning given by Spencer Jones in *Monthly Notices, R.A.S.* **99**, 541, 1939, and that the above formula define also the second.

No change is contemplated or recommended in the measure of Universal Time, nor in its definition.

Subsidiary Recommendations

(*a*) The Conference invites MM. J. H. Oort and H. R. Morgan to agree on a value of the general precession in longitude, suitable for use in the discussion of stellar motions, and to publish the same together with such tables as they may deem desirable. The Conference desires, however, to emphasize that the new value is not to be used in the construction of star catalogues.

(*b*) The Conference regards the improvement of the theoretical motions of the lunar perigee and node as highly important, and hopes that M. W. J. Eckert will speedily complete his research on this subject.

(*c*) The Conference considers as very desirable the early completion and publication of the work of M. Yakovkin on the asymmetry of the figure of the Moon and on the variation of its apparent radius with the librations.

Dirk Brouwer
President of the Sub-Commission

Joint Supplementary Report of the (British) Nautical Almanac Office and the Office of the 'American Ephemeris'

1. *Introduction*

The original Reports, and proposals for discussion, were compiled in December 1950. There have since been several new developments that should be reported to the Commission, and also new proposals relating to the tabulation of the fundamental ephemerides.

H.M. Nautical Almanac Office is, by agreement, responsible for the calculation, and circulation to all countries, of the ephemerides of the Sun, Moon and major planets, the Office of the *American Ephemeris* is responsible for the provision of a large proportion of the fundamental data upon which these ephemerides are based. Moreover, the two Directors have recently had an opportunity for a personal discussion of the detailed problems (particularly as regards time schedules) involved in carrying out the many proposals now under consideration. A comprehensive plan for the incorporation of the proposed changes has accordingly been drawn up and is here submitted to Commission 4 for discussion and approval. Individual proposals will, of course, require discussion by other Commissions (notably Commissions 7, 8, 17 and 31) as well.

Most of these proposals have already been made, either by the (Paris, 1950) Conference on the Fundamental Constants of Astronomy, or in other Reports. The only new proposals introduced here are:

(*a*) The calculation of the lunar ephemeris directly from Brown's theory instead of from his *Tables of the Motion of the Moon*, this is amplified in Section 2.

(*b*) The retention of an additional decimal, to give a tabular accuracy of $0^{s}\cdot001$ in right ascension and $0''\cdot01$ in declination, in the published ephemerides of the Moon and the five outer planets; this is described in Section 3.

A complete list of all the proposed changes is given in Section 4. References are given to relevant publications, but detailed explanations of the consequences of the adoption of the proposals are deferred to an Appendix (p. 93).

In Section 5, a special time-table is proposed for the introduction of some of these changes into the apparent places of stars used for time determination with Photographic Zenith Tubes.

Finally, in Section 6, formal notification is given to the Commission of the unification of the British and American Air Almanacs.

2. *Ephemeris of the Moon*

About 1938 W J. Eckert, using punched-card machines, verified most of the solar portion of Brown's lunar theory, and was able to state that it contained no significant error. Ten years later, in 1948, he used the I.B.M. Selective Sequence Electronic Calculator (S.S.E.C.) to compute the ephemeris of the Moon for one month directly from Brown's numerical theory. This ephemeris has been compared, in the Office of the *American Ephemeris*, with that derived from Brown's *Tables*. After much detailed work, the small, but significant, differences have all been explained; apart from the accumulation of rounding-off errors, and one real error in the construction of the *Tables* (see E. W Woolard, *A.J* **57**, 1952, p. 38), the discrepancies are entirely due to the approximations which Brown necessarily (and legitimately) introduced into the construction of his *Tables*.

The direct calculation on the S.S.E.C. thus offers a lunar ephemeris which will be in strict accord with gravitational theory as expressed by Brown's verified numerical theory, and which will be free from any approximation or accumulation of rounding-off errors.

Arrangements have been made for the ephemeris, as modified by proposal No. 4 in Section 4, to be calculated on the S.S.E.C. as from 1952 January 1, and work has already begun.

It is formally proposed that the ephemeris of the Moon given in the national ephemerides should be based, as soon as practicable, on the values of the longitude, latitude and horizontal parallax calculated on the S.S.E.C.

A recent investigation (G. M. Clemence, J. G. Porter and D. H. Sadler, *Astronomical Journal*, **57**, p. 46, 1952) into aberration in the lunar ephemeris, has shown that, while by far the largest part has been allowed for by implicit changes in the orbital elements as determined by Brown, there remain two small but significant periodic terms in longitude. It is now proposed to incorporate these terms into the apparent longitude.

As will be seen in Section 4, it is not practicable to introduce these changes into the *Nautical Almanac* until 1960. In order, however, to make the modified ephemeris available as soon as possible, H.M. Nautical Almanac Office and the Office of the *American Ephemeris* will jointly prepare, for the years 1952 to 1959 inclusive (for free issue with the *Nautical Almanac* and the *American Ephemeris*), a *Supplement* tabulating for each hour the actual difference between the modified ephemeris and that at present given in the Almanacs.

3. *Additional Accuracy*

The direct calculation of the lunar ephemeris on the S.S.E.C. makes possible the retention of an extra decimal, which is both consistent and real. The accuracy of the present ephemeris is already inadequate for many astronomical-geodetic investigations, and elaborate numerical integrations have been used to determine the Moon's motion accurately over short intervals of time. It is practicable to tabulate the additional figure without significantly increasing the user's work in interpolation, and it is therefore proposed to introduce the additional accuracy into the lunar ephemeris in the *Almanacs* from 1960 onwards, and in the *Supplement* from 1952. This is, in fact, the main object of the direct calculation on the S.S.E.C.

The equatorial rectangular co-ordinates of the five outer planets are now available to nine decimals, which are strictly consistent with gravitational theory. (*Astronomical Papers of the American Ephemeris*, Vol. **12**.) The material is thus available for additional accuracy in the apparent ephemerides, and it is accordingly proposed to tabulate them to the same accuracy as for the Moon $-0^{s}\cdot001$ in R.A. and $0''\cdot01$ in Dec.

4. *Comprehensive List of Proposed Changes*

It is proposed that all the following changes shall be introduced into the national ephemerides, and the international volume of *Apparent Places of Fundamental Stars*, as from 1960 January 1.

(*a*) *Changes Agreed in Principle at the* 1948 (*Zürich*) *Meeting of Commission* 4

1. That nutation should be deduced from the new expansion which has now been completed by the Office of the *American Ephemeris*.

2. That stellar aberration should be computed directly from the motion of the Earth referred to a suitable fixed frame of reference, with the continued omission of terms depending on the eccentricity of the Earth's orbit. Detailed proposals have already been published by J. G. Porter and D. H. Sadler (*M.N.R.A.S.* **110**, 467, 1950).

3. That corrections for annual parallax should be included in the apparent places of those stars, for which the parallax is well determined and sensible.

Proposals Nos. 1, 2 and 3 primarily concern the *Apparent Places of Fundamental Stars*; in view of the other changes proposed, the desirability of giving ample notice and basic data to the Offices responsible for the calculation of the apparent places, and the forthcoming publication of the revised edition of the Yale *Catalogue of Stellar Parallaxes*, it is now proposed to defer these changes to the common date of 1960. H.M. Nautical Almanac Office will thus be able to prepare Day Numbers on the new basis, and a list of adopted parallaxes, in ample time.

(*b*) *Changes Arising from the Paris* (1950) *Conference on the Fundamental Constants of Astronomy*

4. (Resolution No. 2.) 'In order to bring the lunar ephemeris into accordance with the solar ephemeris the Conference recommends that Brown's *Tables of the Motion of the Moon* should be amended by removing the empirical term and by applying to the mean longitude the correction:

$$-8''\cdot72-26''\cdot75T-11''\cdot22T^2,$$

where T is measured in Julian centuries from 1900 January 0 Greenwich Mean Noon.'

The practical implications of this recommendation have been examined (D. H. Sadler, *M.N.R.A.S.* **111**, no. 6, p. 624, 1951), and it has been concluded that the amendments can be made without introducing significant gravitational inconsistencies; the consequential amendments have already been incorporated into the direct calculation on the S.S.E.C.

5. (Resolution No. 4.) 'The Conference recommends that the ephemeris of Mars in the national Ephemerides should be based, as soon as practicable, on the new theory now being constructed at the U.S. Naval Observatory.'

The first-order theory has been published (*Astronomical Papers of the American Ephemeris*, **11**, part II, 1949) and the second-order theory is nearing completion. It has not yet been decided whether to calculate the ephemeris directly from the theory, or to prepare tables in the usual way. In either case it will only be possible to include the new ephemeris for 1960 in the *Nautical Almanac* if it is ready by the end of 1953.

6. (Resolution No. 5.) 'The Conference recommends that the positions of the five outer planets, Jupiter, Saturn, Uranus, Neptune and Pluto, given in the national Ephemerides should be based as soon as possible on the motion of these bodies obtained by the numerical integrations now in progress in the U.S.A.'

The integrations are complete and the results published in *Astronomical Papers of the American Ephemeris*, Vol. **12**.

7. (Resolution No. 6.) 'The Conference recommends that, in all cases where the mean solar second is unsatisfactory as a unit of time by reason of its variability, the unit adopted should be the sidereal year at 1900·0; that the time reckoned in these units be designated *Ephemeris Time*; that the change of mean solar time to ephemeris time be accomplished by the following correction

$$\Delta t=+24^s\cdot349+72^s\cdot3165T+29^s\cdot949T^2+1\cdot821B$$

where T is reckoned in Julian centuries from 1900 January 0 Greenwich Mean Noon and B has the meaning given by Spencer Jones in *M.N.R.A.S.* **99**, 541, 1939 and that the above formula defines also the second.

No change is contemplated or recommended in the measure of *Universal Time*, nor in its definition.'

The consequences of the adoption of this resolution, other than the change of the heading of the time argument of the ephemerides to 'Ephemeris Time' as proposed by G. M. Clemence, are outlined in the Appendix (p. 93).

(*c*) *Change Proposed in the Main Reports*

8. That the short-period terms of nutation should be included in the daily ephemerides of the Sun, Moon and planets.

9. (See Report of the Office of the *American Ephemeris*, p. 81.) That the notation Universal Time (or its equivalent in other languages) in the national ephemerides should be altered to Ephemeris Time (or its equivalent in other languages), except for those sections, such as on eclipses and occultations, where the actual Universal Time is predicted in advance.

(*d*) *Change formally proposed by Dr R. d'E. Atkinson to Commissions* 4 *and* 8

10. 'That from an agreed date all apparent right ascensions shall be tabulated, in the ephemerides, with the nutation of the equinox (tabular "Nutation in R.A.") subtracted from them, and that the "Sidereal time of 0^h" and the "Transit of first point of Aries" shall be correspondingly tabulated without nutation, so that they increase, or decrease, uniformly.'

This proposal is fully analysed in a paper by R. d'E. Atkinson and D. H. Sadler, in *M.N.R.A.S.* **111**, no. 6, p. 619, 1951.

In view of proposal No. 9, it may be desirable to emphasize that the above proposal refers to 'Sidereal time at 0^h U.T.' and 'Transit of first point of Aries in terms of U.T.'

(*e*) *Changes proposed for the first time in this Report*

11. (See Section 2.) That the ephemeris of the Moon given in the national ephemerides should be based on the values of the longitude, latitude and horizontal parallax calculated on the S.S.E.C. directly from the trigonometrical series on which Brown based his tables, as modified by proposal No. 4.

12. (Section 2.) That the ephemeris of the Moon, as calculated according to proposal No. 11, should be further amended by the addition of

$$+0''.018 \cos (l-2D)+0''.007 \cos 2D$$

to the apparent longitude, in order to correct for aberration, which is not fully allowed for in Brown's theory.

13. (See Section 3.) That the ephemeris of the Moon, as calculated according to proposal No. 11, should be given to $0^s.001$ in R.A. and $0''.01$ in Dec.

14. (See Section 3.) That the ephemerides of Jupiter, Saturn, Uranus, Neptune and Pluto, as calculated according to proposal No. 6, should be given to $0^s.001$ in R.A. and $0''.01$ in Dec.

5. *Apparent Places of P.Z.T Stars*

It is desirable that the refinements in proposals Nos. 1 and 2 should be incorporated into the apparent places of stars observed with Photographic Zenith Tubes as soon as practicable. The effect of proposals Nos. 8 and 10 are normally already incorporated. H.M. Nautical Almanac Office hopes to be able to circulate, to all agencies concerned with the calculation of such apparent places, definite values of the Day Numbers *A*, *B*, *C*, *D* by the end of 1952. It is accordingly proposed that the new basis be used rigorously from 1954 January 1 onwards.

The increase in precision indicated by these refinements requires great care in the calculation of the apparent places. A detailed examination of the errors of various procedures is in progress in H.M. Nautical Almanac Office.

6. *Unification of the Air Almanac*

As from 1953 the (British) *Air Almanac* and the *American Air Almanac* will become a single publication, under the title of the *Air Almanac*. It has been designed and prepared jointly by the two Offices to meet the general requirements for air navigation in the United Kingdom, the United States and Canada. The *Almanac* will be printed and published separately in England and America, but will otherwise be identical.

Several changes have been necessary in both publications, but none has any effect on the principles of tabulation or on the use of the *Almanac* for navigation. A general description of the unified *Air Almanac* has been published by G. M. Clemence and D. H. Sadler (*Navigation*, **3**, 9, 1951, and *Journal of the Institute of Navigation*, **4**, 386, 1951).

The *Almanac* was the subject of a recommendation by the Aeronautical Charts Division of the International Civil Aviation Organization (I.C.A.O.) at its recent meeting in Montreal, as follows:

'The Division recommends that the attention of Contracting States be drawn to the availability for reproduction in other countries of the new *Air Almanac* for 1953, already agreed upon for use in Canada, United Kingdom and United States, and that States be informed that it would be more satisfactory for international use, if a list as in the French *Ephémérides Aéronautiques*, were to be added to the existing material defining the abbreviations and symbols used. In advising States, the Organization should explain how proofs suitable for direct photographic reproduction can be made available.'

A list of abbreviations and symbols, such as was suggested by I.C.A.O., has now been incorporated into the *Air Almanac*, together with French and Spanish language equivalents.

Appendix

Explanation and Consequences of the Changes Proposed in Section 4

1. *General.* With the exception of proposals Nos. 4, 7 and 9, little further explanation is required. It is hoped that reprints of all the papers referred to will be available to members of the Commission before the meeting in Rome in September 1952. Some consequences of the adoption of the remaining proposals are, however, outlined in Sections 2 and 3 below.

2. *Day Numbers and Apparent Places of Stars.* A consequence of the adoption of proposal No. 10 is a simplification in the Besselian formulae for correcting for precession and nutation. A much simpler method can in future be adopted for the application of the short-period terms of nutation to the apparent places of 10-day stars. With the short-period terms included in the ephemerides of the Sun, Moon, and planets, the omission of short-period terms will be an unusual requirement; for general use, therefore, the Day Numbers will contain short-period terms. It would appear that Day Numbers, excluding the short-period terms, will be required only for the very limited purposes of calculating the apparent places of 10-day stars; these will be required at intervals of 10 sidereal days only, as at present circulated by H.M. Nautical Almanac Office.

Some minor modifications will be required in the definition of the star constants, and it might be recalled here that corrections for parallax, if less than about 0″·100, can be catered for by constant corrections to the star constants c, d, c', d'

3. *Additional Accuracy.* The extra decimal in the ephemerides of the five outer planets will not materially increase the labour of interpolation for the user, since third and higher differences can still be ignored. This is also the case for the ephemeris of the Moon at hourly intervals.

Before 1960 the user will be able to obtain the right ascension and declination of the Moon on the new basis by:

(*a*) interpolating the hourly ephemeris in the present Almanacs in the usual manner, but retaining the extra decimal introduced in the course of the calculation,

(*b*) applying to the result so obtained the correction obtained by *linear* interpolation in the *Supplement*.

The corrections tabulated in the *Supplement* will include the individual rounding-off errors of the present ephemeris and will therefore not be smooth, but the error introduced by the procedure described above cannot exceed 1·25 units of the extra decimal.

The work of preparing the ephemeris will, of course, be much greater than at present.

4. *Introduction of 'ephemeris time'* The basis of proposal No. 7 (and also of Nos. 4 and 9) is fully described by G. M. Clemence in *Astronomical Journal*, **53**, 169, 1948, the particular relation to proposal No. 4 is also considered by D. H. Sadler in *M.N.R.A.S.* Vol. **111**, no. 6, p. 619, 1951.

It is important that the relationship between sidereal time (S.T.), universal time (U.T.) and ephemeris time (E.T.) should be clearly understood. S.T. is a measure of the rotation of the Earth, E.T. is the independent variable in the solar, lunar and planetary theories, U.T., which involves both the rotation of the Earth and the motion of the Sun round the Earth, is a practical measure of time designed to provide agreement between the mean solar day and the apparent diurnal motion of the Sun. Both S.T. and U.T. are thus dependent on the variable rotation of the Earth and cannot be used as uniform measures of time. This is made evident by the departure of the tables of the Sun, Moon, and planets from observation made in the framework of U.T.; in particular, Newcomb's tables of the Sun fail to represent the position of the Sun in its orbit round the Earth. E.T. is *defined* to be the time referred to which Newcomb's tables will agree with observation, and is as uniform as our present state of knowledge permits. It is related to U.T. by the correction ΔT (this notation is preferred to that given in proposal No. 7) which is determined from the (observed) correction required by Newcomb's tables in order to make them agree with observation in the framework of U.T. Although E.T. is determined from U.T., it is in fact completely independent of it and there is no reason, other than convenience, for measuring it in conventional units; an arbitrary change (or discontinuity) can be made in U.T. without changing E.T., since any change in U.T. is reflected in ΔT

Conventionally, U.T. is 12^h + the hour angle of the mean sun, and is obtained from S.T. by a rigid formula. But owing to the failure of Newcomb's tables to represent the Sun, it is at present 12^h + the hour angle of a 'near' mean sun; this is indicated by the fact that the Sun is not on the meridian at 12^h apparent time, expressed in U.T., but by definition at 12^h E.T. It is part of proposal No. 7 *not* to attempt to correct this so that there will be no discontinuity in U.T. The departure of the Sun from the meridian at noon is unlikely to exceed 30″ (2^s) in the next 200 or 300 years, so that no serious practical difficulties arise.

The present relationship between S.T. and U.T. will thus be retained unchanged:

$$\text{S.T.} = 12^h + \text{U.T.} + 18^h\ 38^m\ 45^s{\cdot}836 + 8640184^s{\cdot}542T + 0^s{\cdot}0929T^2,$$

where T is measured in Julian centuries of 36525 *mean solar days* from 1900 January 0·0. The last three terms are numerically equal to the right ascension of the mean sun (R.A.M.S.), according to Newcomb, and the effect of the present proposals is to define the actual value of R.A.M.S. by regarding T as measured in E.T. instead of U.T.

Now, one effect of proposal No. 9 is to bring the solar ephemeris into accord with observation, by retaining unchanged the ephemeris from Newcomb's tables and replacing the argument U.T. by E.T. Although this is strictly in accord with the wording of Resolution No. 3 of the Paris Conference on Fundamental Constants, it does imply that an ephemeris of the Sun calculated in the framework of U.T. would be discontinuous with the one we have always known, which although labelled U.T. has in fact been in the framework of E.T. This discontinuity is precisely the difference in R.A.M.S. caused by measuring T in E.T. instead of in U.T.

It is, in fact, impracticable to obtain consistency (and thus agreement with observation in the framework of U.T.), since it would imply that a term $\Delta T/365{\cdot}2422$ be introduced into the relationship between S.T. and U.T., as ΔT is unknown, except in arrear, it would thus be impossible to deduce U.T. from the observed S.T. If desired, a closer agreement can be made at any time by introducing a discontinuity of the instantaneous value of $\Delta T/365{\cdot}2422$ into the measure of U.T. and amending the relationship between S.T. and U.T. accordingly; neither S.T. nor E.T. would be affected.

A general picture of the ephemerides can now be presented. The fundamental ephemerides of the Sun, Moon and planets will all be tabulated with argument E.T. Ephemerides at transit (if given) will, however, have to be based on extrapolated values of ΔT Sidereal time will be tabulated with argument U.T., and the U.T. of the transit of the first point of Aries will be given as at present, and based on precisely the same formulae.

All predictions designed to facilitate observation, such as eclipses, occultations, physical ephemerides of the Sun, Moon and planets, will be given with argument U.T., based on an extrapolated value of ΔT Navigational ephemerides will, of course, be given with U.T. as argument. It is only for the Moon that there will be any large difference; many of the ephemerides will be unchanged.

Theoretical work on the orbits of comets and minor planets will, of course, be done entirely in the framework of E.T. Discovery orbits and search ephemerides will, however, have to be related to U.T., though the accuracy required is such that there will probably be no practical difference between the use of E.T. and U.T.

It must be emphasised that E.T. is intended for use primarily as the uniformly-increasing independent argument for the positions of the Sun, Moon, and planets in their orbits, it is not normally intended for the calculation of hour angle, which is related directly to the Earth's rotation.

5. *Amendment of the Lunar Ephemeris.* The amendment of the lunar ephemeris as in proposal No. 4 requires great care; it has already been described in detail in the references given. Apart from possible errors in the numerical values of the observationally-determined coefficients, the amended ephemeris of the Moon will agree with observation in the framework of E.T. ΔT may thus be determined directly from observations of the Moon by comparing the U.T. of observation with the E.T. for which the ephemeris agrees with the observation. This will hold however large ΔT may become.

The correction to the Moon's mean longitude, in the framework of U.T., is made up of two parts, of which the amendment to the lunar ephemeris is one and the other corresponds to ΔT In the time interval ΔT all the arguments of the lunar theory change. With the lunar ephemeris on its present basis, it will not therefore be practicable to make the large corrections which will undoubtedly be required in the future, without introducing gravitational inconsistencies.

A separate ephemeris will, in either case, be required for navigational purposes; further, it seems essential that the ephemeris at transit must be calculated for a U.T. close to the actual time of transit, in order to facilitate the reduction of the transit observations. This duplication could only be avoided by adopting, many years in advance, an approximate value of ΔT or, in the present system, of a correction to mean longitude.

6. *General Comments on the Introduction of Ephemeris Time.* From the point of view of dynamical astronomy it is essential to have a uniform time scale, to which to refer the motions of bodies in the solar system, ephemeris time fulfils that requirement, to the best of our present knowledge.

In particular, it enables the ephemerides of the Sun and Moon to be based on consistent gravitational theory and thus to be calculated many years in advance. This can only be achieved, however, by the use of observationally determined secular accelerations, which cannot be entirely free from error. These cannot be fully separated from the 'fluctuation' in the Moon's mean longitude (B), but the ratio of their magnitudes in the longitudes of the Sun and Moon is different from that of their motions in mean longitude. As ΔT, theoretically defined by the Sun alone, is in practice determined from observations of the Moon, inconsistencies may arise in the future. The uncertainties in the numerical values of the secular accelerations are, however, such that no serious departure from uniformity is likely to arise in ephemeris time for several centuries. Any defects in the present theories of the Sun and Moon are unlikely to be of importance as regards the long-term determination of ΔT

The main practical reasons for the introduction of E.T. as the argument of the ephemerides are thus that its definition can remain unchanged for a long time, and that it greatly facilitates the comparison of observation with theory, though perhaps (in some cases) not with the tabulated ephemeris. These are just the primary requirements of the fundamental ephemerides, which are, of course, only secondarily intended to facilitate observation. It is difficult to see what other method would offer similar advantages: continuation of the present basis of tabulation would soon lead to large

corrections, which in the case of the Moon would be extremely difficult to make, and to separate ephemerides for practical purposes; the introduction of frequently changed corrections, either to time or mean longitude, would make impossible calculation and publication several years in advance and the discontinuities would be most undesirable.

There can be no doubt of the need for insistence on both gravitational consistency and high accuracy; the present ephemerides are already inadequate for two practical requirements—accurate long-term time keeping and geodetic connections between continents.

Remarques sur le 'Joint Supplementary Report' des 'Almanac Offices' de Greenwich et Washington à la Commission 4 de l'U.A.I.

Les remarques suivantes concernent principalement le calcul des éphémérides de positions stellaires apparentes.

1. Dans les éphémérides de 10 jours, on ne doit, pour permettre une interpolation exacte, conserver aucun terme à courte période. La possibilité de calculer ces termes, s'ils ne sont pas fournis séparément, doit faire l'objet d'un supplément.

Dans les *constantes pour la réduction*, les quantités A, B, C, D, E doivent donc être données, pour chaque jour, avec la signification adoptée jusqu'à présent, c'est-à-dire ne contenant pas de termes à courte période. Ensuite, pour chaque jour, les termes à courte période A', B' et (conformément à *M.N.* **110**, 471) les termes à courte période relatifs à l'aberration $C' = (\Delta C)$, $D' = (\Delta D)$.

Pour faciliter le calcul des éphémérides de 10 jours, il convient de fournir les constantes de réduction sans les termes à courte période, donc également sans C' et D'

2. On estime qu'il ne convient pas d'adopter la proposition, formulée par le Dr Atkinson, de donner, dans les éphémérides stellaires, les A.R. débarassées de la nutation et de l'abérration. Les 2 coordonnées A.R. et Décl. appartiendraient à deux systèmes différents ce qui souvent, par exemple en géodésie, provoquerait des confusions et détruirait l'homogénéité de la publication.

La difficulté qui subsiste dans la pratique (en raison de la précision de la marche des garde-temps modernes) est aisée à surmonter ou même, elle l'est déjà. Dans l'*Astronomish-Geodätisches Jahrbuch*, toutes les données numériques, sans exception, renferment les termes à longue période; ceux à courte période sont fournis séparément, ou l'on donne des procédés pour en effectuer rapidement le calcul.

Dans l'éphéméride du temps sidéral pour 0^h T.U., sont donnés, en outre, les termes à longue période relatifs à la nutation. (Depuis le vol. 1931 de *B.J.*) Ceux-ci peuvent être retranchés du temps sidéral, pour passer à un équinoxe moyen. Il est très simple, dans chaque détermination de temps, d'apporter cette réduction au résultat pour en conclure l'état d'une pendule de temps sidéral par rapport à l'équinoxe moyen.

Il faudra réduire d'une façon analogue le temps sidéral du *Jahrbuch* lors de sa transformation en temps moyen.

3. Pour l'homogénéité des publications, il serait désirable que les Ephémérides du Soleil, de la Lune et des Planètes continuent à être données sans termes à courte période d'origine lunaire.

4. Conformément aux propositions, *le temps des éphémérides* sera employé dans l'*Astronomisch-Geodätisches Jahrbuch.*

A. Kopff

Astronomisches Rechen-Institut, Heidelberg
le 8 mars 1952

Proposal to Commission 4 from the Japanese National Committee

Subject. To express one of the Besselian day numbers A in the computation of apparent places of stars, in units of seconds of arc, by multiplying it by the nutation constant n, and accordingly to divide by n the corresponding star constants a and a'

Reason. (1) By expressing A in the unit of seconds of arc, the required accuracy will be attained for all of the day numbers in a uniform system.

(2) In computing the star constants a and a' we can omit the additional process of multiplying by n, the nutation constant.

(3) It will be more elegant with regard to uniformity to express A together with the other day numbers B, C, D and E in one number system, and there is no inconvenience in doing so.

Illustration. The new system has been adopted in the Japanese *Ephemeris* since 1943 and its advantages have been fully acknowledged.

Rapport Supplémentaire

L'Institut d'Astronomie Théorique de l'Académie des Sciences de l'U.R.S.S. a continué de publier régulièrement *l'Annuaire Astronomique de l'U.R.S.S. L'Annuaire* pour 1953 a paru en octobre 1950. Celui pour 1954 est sous presse.

A partir de *l'Annuaire* pour 1952, on a considérablement augmenté le nombre des étoiles pour lesquelles on fournit les éphémérides. Les étoiles ajoutées récemment ont été choisies de telle façon que la zône de 0° jusqu'à $-40°$ en déclinaison se trouve recouverte, par les étoiles de *l'Annuaire*, le plus uniformément possible. On a ajouté quelques étoiles brillantes, dont la déclinaison est entre $-40°$ et $-70°$ et qui sont indispensables pour *l'Annuaire Nautique de l'U.R.S.S.* En tout on a ajouté 119 étoiles FK3.

Dans *l'Annuaire* pour 1952, les positions moyennes sont données pour 752 étoiles au lieu de 633; les positions apparentes des étoiles de 10 en 10 jours sont fournies actuellement pour 609 étoiles au lieu de 490. De plus, dans le volume pour 1951 et les suivants, on donne les positions apparentes pour 37 étoiles circompolaires boréales, au lieu de 36.

L'élaboration de *l'Annuaire Astronomique de l'U.R.S.S.* a été faite selon les principes de coopération fixés par l'Union Astronomique Internationale. D'après les données communiquées régulièrement par le Nautical Almanac Office, on a publié, dans *l'Annuaire*, les coordonnées de la Lune et des planètes. Jusqu'à 1952, on a publié aussi, d'après la même source, les coordonnées du Soleil, ainsi que les données concernant les occultations d'étoiles par la Lune, pour 14 observatoires Soviétiques.

De son coté, l'Institut d'Astronomie Théorique a communiqué régulièrement les positions apparentes des étoiles calculées pour *l'Annuaire*, ainsi que les positions apparentes des étoiles qui ont été calculées spécialement pour le volume *Apparent Places of Fundamental Stars*.

A partir de 1953, conformément à la résolution de l'U.A.I. (Zürich, 1948), on effectue le calcul des réductions au jour en utilisant les 'Day Numbers' communiqués par l'Office du Nautical Almanac.

Prof. M. Subbotin

Report of Meetings of Commissions 4 *and* 4a

For the first meeting on Monday, 8 September 1952, Prof. Brouwer was in the chair, and twenty-two members and others were present.

The Chairman said that the principal business before the joint meeting was the discussion and approval of the resolutions of the Paris (1950) conference on the fundamental constants of astronomy, as printed in the *Draft Reports* (see p. 88).

Resolutions No. 1 (fundamental constants) and No. 3 (tables of Sun, Mercury and Venus) were agreed without discussion.

Speaking on Resolution No. 4 (ephemeris of Mars), Dr Clemence said that the complete theoretical expansion would be finished by about the end of 1952, but that no decision had yet been made as to whether to construct tables, or to calculate the ephemeris directly from the trigonometrical expansion. Discussion on the merits of the two methods took place between Dr Belorizsky and Dr Clemence, while Dr Riabov spoke on the advantages of numerical integration as compared with classical theory. Dr Brouwer pointed out that numerical integration offered almost insuperable difficulty in the case of Mars. The resolution was then agreed.

Resolution No. 5 (orbits of the five outer planets) was considered; Dr Clemence reported that the heliocentric equatorial rectangular co-ordinates had now been published for the years 1653 to 2060 in vol. **12** of the *Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac*. In the discussion a general desire was expressed for a more detailed publication of the comparison between the new ephemerides and the existing tables, and of the osculating elements. M. Fayet said that he would probably give this comparison at a uniform interval (? one month) in the *Connaissance des Temps*; and Mr Sadler undertook, on behalf of the (British) Nautical Almanac Office, to calculate osculating elements at intervals of at most one year. The resolution (No. 5) was then accepted unanimously.

Dr Clemence reported briefly on the necessity for Resolution No. 6 ('ephemeris time'), in that a uniform time was now essential for many theoretical and practical investigations. The resolution was agreed in principle, but consideration of the name for the uniform time was deferred to a subsequent meeting.

The meeting was continued in the afternoon, with M. Fayet in the Chair.

The Chairman reported that Commissions 7, 17 and 20 had, earlier in the day, approved Resolution No. 2 (ephemeris of the Moon), and he accordingly put this resolution to the meeting. It was approved unanimously

A long discussion took place on the terminology to be used for the uniform time defined in Resolution No. 6, some members (Dr Atkinson and others) objecting to 'ephemeris time' on the grounds that certain ephemerides must continue to be given with universal time as argument. Prof. Kopff pointed out that the time defined by the resolution was in any case empirical. Eventually it was agreed to accept the name 'ephemeris time' Dr Atkinson queried the necessity for the last sentence of the resolution, but withdrew his objection after explanation by Dr Clemence. The complete resolution was then adopted, but it was noted that it would need confirmatory approval by Commission 31.

It was agreed that the work of Commission 4*a* was now complete, and the following resolution was adopted for transmission to the Executive Committee:

Commission 4 and 4*a* recommend that Commission 4*a* be dissolved, its work having been completed.

The Commissions then proceeded to a systematic discussion of the proposals contained in the Joint Supplementary Report of the (British) Nautical Almanac Office and the Office of the American Ephemeris (*Draft Reports*, see p. 90); the resolutions following are referred to by the numbers in that Report.

It was agreed unanimously to adopt the date of 1960 January 0 for the introduction of proposals Nos. 1, 2 and 3 (new expansion of the nutation, new form of stellar aberration, and corrections for annual parallax) which had been previously agreed at the Zürich (1948) meeting.

Nos. 4, 5, 6 and 7 had already been agreed at earlier sessions as resolutions (Nos. 2, 4, 5 and 6 respectively) of the Paris meeting on the fundamental constants of astronomy.

In the discussion on proposal No. 8 (short-period terms of nutation) Dr Nemiro and Prof. Zverev gave an account (summarized in an appendix to this report) on the work of E. P Fedorov on the comparison of the classical theory of nutation with observational data. It was, however, pointed out that the previously agreed resolutions called for no change in the adopted value of the constant of nutation, and proposal No. 8 was accordingly adopted unanimously.

Proposal No. 9 (ephemeris time as argument in the national ephemerides) was agreed without discussion.

Discussion on proposal No. 10 (the 'Atkinson proposal') was deferred until after the joint meeting with Commission 8, and that on proposal No. 11 (ephemeris of the Moon direct from the series) had to be interrupted.

At a joint meeting with Commissions 8 and 8*a*, in the afternoon of 8 September, proposal No. 10 (the 'Atkinson proposal') in the Joint Supplementary Report was discussed at length and in detail. Dr Atkinson explained the proposal, but objections were raised by Prof. Danjon and Prof. Kopff. As it seemed unlikely that a conclusion could be reached on this day, consideration was again deferred.

On Wednesday 10 September, Commissions 4 and 4*a* met jointly with Commissions 7, 8, 8*a*, 17, 20, 20*a* and 31, with M. Fayet in the Chair. Eighty-two members and others were present.

Dr Clemence proposed the following resolution which, after some discussion, was agreed unanimously

Following a practice introduced by W de Sitter, the term 'astronomical time' has been used to designate time measured by the rotation of the Earth. Since ephemeris time is also measured by astronomical means, it is recommended that this use of the term 'astronomical time' be discontinued. The terms 'mean solar time' and 'sidereal time' are available for the designation of time measured by the rotation of the Earth; if a more general term is needed, the term 'rotational time' is recommended. There is no objection to the continued use of the term 'Greenwich mean astronomical time' in the conventional sense.

The Chairman then called upon Dr Alexander Wilkens (Observatorio Astronomico, Eva Peron, Argentine) to give an account of his paper on the acceleration in the mean motion of comet Encke. The following is a summary of Dr Wilken's contribution:

The object of the investigation is to see if the known anomaly of the secular variation of the mean motion of comet Encke is explicable solely on the basis of Newtonian gravitation. An attempt is made with the help of the Poisson terms of the mean major axis in the form

$$\Delta n = ct \sin(\alpha t + \beta),$$

where n = mean daily motion, and c, α and β are constants. The period $2\pi/\alpha$ must be large, and α must be small, if Δn is to appear to be secular in character for a long time. The coefficient α is based on the very close commensurability of the mean motions of the comet (n) and Jupiter (n'); $\alpha = 5n - 18n'$ has an absolute value less than $4''$ The critical terms are deduced by numerical development of the perturbing function in a Fourier series with the two mean longitudes as arguments; this extensive work is controlled by a new method based on the derivation of invariants—integrals of Poincaré type deduced with the help of the differential variations of the problem. The results are being completed and will be published as soon as possible.

Dr Brouwer said that Backlund had examined the motion of Encke's comet by precise numerical integration, which included all powers of the disturbing forces; if this work is correct, the acceleration cannot be explained by Newtonian gravitation.

Discussion was resumed on proposal No. 10 (the 'Atkinson proposal'), which had been deferred from previous meetings. Dr Atkinson proposed that it should be referred to the Directors of the national ephemerides, with power of adoption if they agreed that it was desirable. Prof. Danjon agreed in principle, but desired that observers, as well as the compilers of ephemerides, be consulted. It was eventually agreed that the President of Commission 4 be authorized to conduct an inquiry among the members of Commissions 4 and 8, with a view to reaching agreement on this proposal, and the name to be given to the new co-ordinate, in time for it to be incorporated (if agreed) in the ephemerides at the same time as the other changes now recommended.

It was stressed that it was essential that the change should be made at the same time in all the national ephemerides.

Proposals No. 11 (ephemeris of the Moon directly from the series), No. 12 (aberration in the lunar ephemeris), and No. 13 (additional accuracy in the lunar ephemeris) were then discussed together. Dr Clemence explained that the longitude, latitude, and horizontal parallax of the Moon for the years 1952–71 inclusive would be completed and circulated before the end of 1953. Prof. Brouwer suggested that the words 'on the S.S.E.C.' be omitted from proposal No. 11. With this amendment proposals Nos. 11, 12 and 13 were carried unanimously.

In the discussion on proposal No. 14 (additional accuracy in ephemerides of the outer planets), Dr Clemence explained that its main purpose was to give positions of Uranus, Neptune and Pluto to the same accuracy as for the stars. The proposal was agreed.

The Chairman now introduced the proposal relating to the definition of the day number A, as made by the Japanese National Committee (*Draft Reports*, see p. 97). Dr Clemence stated that he supported the sense of the proposal but would like it to be reworded in the following precise terms:*

It is recommended that, beginning on 1960 January 0, the Besselian day number A be expressed in seconds of arc by multiplying it by Newcomb's value of the coefficient of the annual precession in declination

$$n = 20''.0468 - 0''.0085T$$

(T measured in Julian centuries from 1900 January 0 Greenwich Mean Noon) and that the star constants a and a' be divided by n, so becoming pure numbers.

It was agreed to in this form.

The Chairman read a letter from Mr Jelstrup, requesting that the tables of moonrise and moonset in the national ephemerides should be extended to north latitudes 70° Mr Sadler stated that these values were available (up to lat. N. 72°) in the navigational almanacs and that there did not appear to be sufficient astronomical demand for their inclusion in the ephemerides; the Directors of the national ephemerides would, however, give consideration to the request.

Mr Sadler then made the following proposal, which was agreed unanimously:

At the Zürich (1948) meeting, Commission 4 gave its approval to an informal arrangement between the British Nautical Almanac Office and the U.S.S.R. Institute for Theoretical Astronomy in Leningrad for the calculation, for the international volume *Apparent Places of Fundamental Stars*, of those 10-day stars previously supplied by the Office of the Connaissance des Temps. This arrangement, by which the Institute for Theoretical Astronomy undertook the calculation of the apparent places of 210 stars, while the Nautical Almanac Office undertook the remaining 216 stars, has worked well and the Commission is grateful to the Institute for Theoretical Astronomy for undertaking this work at such short notice and the supplying the computations well in advance of the dates requested.

It is accordingly proposed that this arrangement be formally confirmed.

Mr Sadler drew attention to the work being done at the Astronomische Rechen-Institut in Heidelberg on the revision of the FK3 catalogue and proposed.

The Commission expresses its satisfaction that the Astronomische Rechen-Institut at Heidelberg will undertake the revision of FK3 using the observations obtained since its formation, and that a supplement of FK3 containing brighter stars (to about 7th magnitude) is to be constructed. As to the fundamental catalogue of faint stars, a special agreement is necessary; this catalogue should be strongly connected with the system of FK3.

Dr Clemence supported this resolution and Prof. Kopff gave a short explanation of the work being done at Heidelberg; the resolution was agreed unanimously.

Mr Sadler referred briefly to the unification of the British and American air almanacs

* In the resolution as originally approved, the expression for n was erroneously given as 'the constant of nutation 9″.210'; this was changed subsequent to the meeting.

(*Draft Reports*, see p. 92) and showed copies of the British edition of the joint *Air Almanac* for 1953 January–April. He also reported that the *Abridged Nautical Almanac* had been completely redesigned as from the year 1952, to give direct tabulation of Greenwich Hour Angle, and showed a copy to the meeting.

Appendix

Summary of E. P Fedorov's paper 'On a comparison of the classical theory of nutation with observation'

To the first order, nutation in declination may be written

$$\Delta\delta = N_0(-n_0 \cos\alpha \sin\Omega + \sin\alpha \cos\Omega), \tag{1}$$

where N_0 is the constant of nutation and n_0 is the ratio of the axes of the nutational ellipse $= \cos 2\epsilon/\cos\epsilon$. The amplitude of the nutational changes in declination is thus

$$A = N_0(n_0^2 \cos^2\alpha + \sin^2\alpha)^{\frac{1}{2}}. \tag{2}$$

If the accepted value of n_0 is erroneous, corrections to N_0 cannot be obtained directly from an analysis of A derived from latitude observations, since they will depend on right ascension. ΔN_0 is accordingly expressed in the form:

$$\Delta N_0 = \Delta N + \frac{N_0 n_0}{n_0^2 + \tan^2\alpha}\,\Delta n \tag{3}$$

and the latitude observations analysed for ΔN and Δn.

Only the most extensive and homogeneous series of observations can be used. A rediscussion of the Pulkovo observations during 1915–41 (originally made by K. A. Kulikov) using equation (3), gave

$$\Delta N = -0''.020 \pm 0''.008; \quad \Delta n = +0{\cdot}0027 \pm 0{\cdot}0009.$$

Przybyllok's discussion of the International Latitude Service observations for 1900–14 has been used in the same way to give (after averaging the results for all five stations)

$$\Delta N = -0''.014 \pm 0''.005; \quad \Delta n = +0{\cdot}0026 \pm 0{\cdot}0007.$$

In determining the constant of nutation from the Greenwich observations with the floating zenith tube, Jackson used the differences of the latitude determined from morning and evening groups. This requires the following modified form for equation (3)

$$\Delta N_0 = \Delta N + \frac{N_0 n_0}{n_0^2 + \cot^2\alpha'}\,\Delta n, \tag{4}$$

where α' is the mean right ascension of the morning and evening groups. Rediscussion of Jackson's reductions for 1911–28, on the basis of equation (4), leads to

$$\Delta N = -0''.010 \pm 0''.001; \quad \Delta n = +0{\cdot}0022 \pm 0{\cdot}0003.$$

The following table gives the values of the coefficients of the main terms of nutation. (*a*) assuming n_0 is constant, and (*b*) derived as above.

Series of observations	(*a*)		(*b*)	
Pulkovo, 1915–41	9″.206	6″.849	9″.190	6″.886
International Latitude Service, 1900–14	9″.207	6″.850	9″.193	6″.874
Greenwich 1911–29	9″.207	6″.850	9″.200	6″.874

In all three cases Δn is positive and averages $+0{\cdot}0025$; the classical theory thus does not accord with observation.

An analysis of the International Latitude observations of 1899–1934 has been carried out for Carloforte (66,220 observations) and Ukiah (65,736 observations) for the 'nutational' and 'tidal' half-monthly terms. After allowing for the omission of short-period terms in the reductions used for the apparent places of stars, the following expressions were obtained:

	Carloforte		Ukiah	
Nutational wave	$0''.011 \sin (2\,\mathbb{(} - \alpha - 10°)$		$0''.011 \sin (2\,\mathbb{(} - \alpha - 4°)$	
	± 1	± 4	± 1	± 6
Tidal wave	$0''.009 \cos (2\,\mathbb{(} - 2\alpha - 104°)$		$0''.007 \cos (2\,\mathbb{(} - 2\alpha - 91°)$	
	± 1	± 3	± 2	± 15

The tabular value of the coefficients for the term $\sin (2\mathbb{(} - \alpha)$ in the expression for the nutation is $0''.085$, so that the value deduced from observations is $0''.096$. This value should be compared with the coefficient $0''.078$, which is obtained after correction for the difference between the momentary axis of rotation of the Earth and the polar axis of inertia. There is thus a discrepancy between theory and observation of $0''.018$, and it seems impossible to explain this by the influence of elastic deformations of the Earth and of the tides; it must be the result of the dynamical effect of the liquid core of the Earth.

https://doi.org/10.1017/S0251107X00032260 Published online by Cambridge University Press