31. COMMISSION DE L'HEURE

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We note with deep regret the death of Prof. E. Guyot, who made valuable contributions to time services, and also to the study of double stars.

Since the eleventh General Assembly of the IAU there has been a further increase of precision in the determination and keeping of time at many observatories and institutions. In fact an international service of atomic time has been set up.

ASTRONOMICAL DETERMINATION OF TIME

According to the recommendation of the IAU (resolution 59) the new fundamental catalogue (FK4) is now used for all astronomical determinations of time.

Besides the usual reversible transit instruments, photographic zenith tubes (PZT) and Danjon astrolabes have been more widely used for observations.

The results of astronomical observations for all the time services are corrected for the motion of the Earth's poles, as calculated by the Bureau International de l'Heure (BIH). This rapid polar motion service (SIR) is speedily developing: only four stations participated in 1956 and their number reached 27 in 1963. The great regularity and high quality of this work of the BIH must be pointed out.

Time keeping. Most time services are now using quartz crystal clocks instead of the former pendulum clocks. However, Ph. Fedčenko (1) in the U.S.S.R. has improved the pendulum clock by inventing an isochronic suspension using an electromagnetic impulse and improved temperature compensation. The diurnal variation of rate is about 0·2 ms, which corresponds to a quartz clock of average quality. In various places work on the improvement of quartz clocks is going on so as to reduce the ageing of the crystal and increase the stability of rate. More atomic standards, chiefly of caesium, are being used as fundamental time keepers. From 1961, January, atomic time has been published in the *Bulletin Horaire;* it is based on 10 different sources and can be considered as a permanent service of atomic time. According to the BIH, six of the best atomic standards give a yearly integrated error of about 0·3 ms. At several places, work on hydrogen masers is being carried out.

Time and frequency signals. The transmission of time and frequency by radio is mostly on atomic time, reduced to U.T.2 by applying corrections calculated by the BIH. In several countries a co-ordination of transmission of time and frequency has been reached (Argentine, Australia, Italy, Japan, England, U.S.A., Canada, Switzerland, Czechoslovakia, S. Africa). The reception of time signals is usually made by means of cathode oscillographs, which has diminished the error of reception to a few 0·1 ms. In view of this, from 1961 the 'Heures définitives' have been published with four decimal places. In the U.S.S.R. such a publication for standard time was begun in 1959. A great increase of precision in the comparison of time between remote observatories can be accomplished by means of artificial satellites of the Telstar type. An experiment of such a comparison between the Royal Greenwich Observatory and the U.S. Naval Observatory in Washington in August 1962 showed that a transatlantic comparison can be made with a precision of one microsecond, but the connection between the ground station (Goonhilly) and the Royal Greenwich Observatory is limited to $\pm$ 20 μs.

The International Geophysical Year. Longitude determinations made during the International Geophysical Year (IGY) at the BIH gave new values for the 53 stations participating in the third international longitude determination. The mean error of a longitude for 1957–1959 was $\pm$ 0·003 sec, whereas at the determinations of 1926 it was $\pm$ 0·027 sec and of 1933 $\pm$ 0·017 sec, this being partly due to a much longer period of observation—30 months instead of two months. The BIH continued its investigation on the velocity of propagation of electromagnetic waves, improvement of star positions etc. Several catalogues of star positions observed by the different time services during the IGY and adjacent years were published. Of these the largest is the catalogue containing 671 stars observed in Paris by B. Guinot *et al.* (**2**), as well as the catalogue of right ascensions observed at Pulkovo with a transit instrument by Pavlov *et al.* (**3**). The precision of these catalogues is not inferior to that of the FK4. At Pulkovo work is continuing on the setting up an independent catalogue on the basis of about 150 000 observations made at time services of the U.S.S.R.

Change of rate of the rotation of the Earth. This question attracted much attention. A. Danjon found an interesting correlation between the change of the velocity of the Earth's rotation and the change of the nuclear component of cosmic radiation (**4, 5**). M. Rochester investigated the possible connection between the western geomagnetic drift and the irregularities of the rotation of the Earth. D. Belotserkovsky, using the results of astronomical observations of time services of the U.S.S.R. for eight years from 1955 to 1962 inclusive, found a sufficiently pronounced change with a period of a quarter year and an amplitude of several milli-seconds (**7**). N. Pavlov and G. Staritsyn have shown a possible connection between seasonal changes of mean temperatures in northern Eurasia and the seasonal term in the Earth's rotation (**8**). N. Pavlov and A. Chelombitko, from an analysis of the results of observations at Pulkovo and Zi-Ka-Wei in 1962, found apparently irregular variations of the speed of the Earth's rotation with a period of about one month (**9**). Although the amplitudes of these variations are only about 0·01 sec, the arising accelerations are many times greater than for the annual term.

Determination of the unit of time. In 1960 at the eleventh General Conference on weights and measures it was recommended that research on atomic standards of frequency be intensified in order to make possible a proposal for an atomic unit of time at the twelfth General Conference in 1966. The Consultative Committee for the Definition of the Second (CCDS) recommended that intercomparisons of different atomic standards in laboratories and by radio-transmission be made as widely as possible; it was also recommended that information about the results of the experiments and techniques be published as speedily as possible. Complying with this, at several places work on improving hydrogen masers is being done. At Harvard a relative stability of the order of 10^{12} to 10^{13} has been reached for two hydrogen masers. In May 1963, the U.S. Naval Observatory, the Office of Naval Research of the U.S.A., and the BOMAC laboratories have determined the frequency of the hydrogen line relative to the second of ephemeris time.

Although the hydrogen masers promise to be very precise, it is not quite certain that they will exceed the precision of caesium atomic clocks, which attains $1 \cdot 10^{-11}$, or other types of atomic clocks. Not yet formally introduced, the atomic second is being used in practice as a measure of intervals of time. A preliminary frequency of 9 192 631 770 cycles per sec. is used for caesium in a zero field.

REPORTS OF OBSERVATORIES AND LABORATORIES

Alger. Astronomical observations are made with a Danjon astrolabe, OPL no. 8. A standard frequency by James Knights is received in addition to five crystal clocks by Ebauches-Neuchâtel which were used during the IGY, i.e. 1957–63. In 1962, November, Dr L. Arbey was appointed director of the Observatory.

Belgrade. Pour la détermination de l'heure on a employé deux instruments des passages et pour la conservation de l'heure on a introduit les trois horloges de quarz Schwarz-Rhode, et on a reçu régulièrement six émissions de signaux horaires. Les résultats furent régulièrement communiqués au BIH et publiés dans le Bulletin de l'Observatoire. Z. Brkič a terminé la déduction définitive de la longitude de l'Observatoire du matériel des années 1958–59 et la discussion de ses variations saisonnière et séculaire.

Besançon. Les instruments utilisés sont les suivants:

1. Astronomie.

Un astrolabe impersonnel Danjon OPL 31 utilisé depuis février 1961 en remplacement de l'astrolabe prototype obligeamment prêté en 1958 par l'Observatoire de Paris.
Un chronographe électronique Belin imprimant la milliseconde doit être remplacé au cours de l'été 1963 par un chronographe totalisateur Ebauches S.A.

2. Réception des signaux horaires.

Les mesures sont effectuées à l'aide d'un oscilloscope électronique permettant l'appréciation du dixième de milliseconde.

3. Garde-temps.

Deux horloges à quartz Ebauches S.A. (fréquence 100 KHz).
Une horloge à quartz James Knights (fréquence 1 MHz).

Le programme d'observation comprend 12 groupes de 1,5 h centrés sur les heures sidérales paires. Ces groupes comprennent en moyenne 28 passages. Au total 270 étoiles (217 du FK4 et 53 du Supplément) sont observées, parmi lesquelles 69 lors de leurs deux passages.

28 réceptions journalières des signaux horaires sont effectuées de $7^h\ 50^m$ T.U. à 17^h T.U. Les résultats de ces mesures sont publiés en T.U. 2 demi-définitif dans les circulaires mensuelles de l'Observatoire.

Les comparaisons des échelles de temps commencées en 1959 se sont poursuivies en attendant de pouvoir rattacher régulièrement, fin 1963, l'horloge directrice au maser à ammoniac construit à Besançon.

Bucarest. Le service horaire de l'Observatoire de Bucarest publie mensuellement le Bulletin T.U. 2, et a été introduit dernièrement dans l'observatoire moyen.

Les recherches théoriques concernant le mouvement de rotation de la Terre sont développées à partir des équations d'Euler généralisées en connexion avec les propriétés élastiques.

Canberra. Time determinations were continued with the PZT, and early results on punched tape are being transferred to cards for investigation. Data-processing equipment has been programmed to do most regular operations such as the reduction of star, clock and time-signal observations and the typing of reports. Results are radioed weekly to the Royal Greenwich Observatory in connexion with preliminary corrections. The adjustments for Belconnen time signals have been made more precise, and two Essen-ring quartz oscillators and very low frequency (v.l.f.) tracking receiver have been installed.

Greenwich. Royal Greenwich Observatory. Astronomical observations for Time Determination were continued with the Photographic Zenith Tube, at the rate of over 100 plates per year with an average of 10 stars per plate, until the instrument was taken out of service in July 1962 for overhaul, examination and adjustment. A limited programme of observing recommenced in December 1962, and full operation in July 1963.

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Since May 1960, the complete reductions have been performed on an ICT 1201 electronic computer.

The Danjon astrolabe has been in regular use, and more than 700 groups have been observed since observations began in 1959. The results obtained up to February 1962 have been used to establish a system of corrections to the adopted zenith distances, and these have been used in the reduction of all groups to date. The reductions have been performed on the ICT 1201. A preliminary discussion of the results has provided group corrections in time and latitude.

Two atomic time scales, both derived from the National Physical Laboratory caesium standard, have been determined at the Royal Greenwich Observatory. One scale Cs (EB) (originally denoted Cs 1) was commenced in June 1956: the other Scale Cs (H 12) commenced in July 1957 when the two scales were in agreement. Figures for the second scale have been published since January 1958. Since 1957, the two scales have differed by amounts up to 2 ms, but the difference is not divergent. The difference between A1 and Cs (H 12) has remained constant to within four ms since the beginning of 1959.

A 'nominal' clock has been installed at the Royal Greenwich Observatory to provide timing signals which can be adjusted to the adopted rate of U.T. 2 to an accuracy of one part in 10^{10}. The output from one of the quartz clocks, which may differ from nominal by as much as one part in 10^6, is continuously adjusted by a 100 kHz phasing unit driven through a gearbox, the ratio of which may be adjusted in unit stages from plus to minus 1 to 9999.

The Royal Greenwich Observatory has participated in the co-ordinated transmissions since 1960 April 1. The preliminary correction to time signals issued by the Royal Greenwich Observatory and the U.S. Naval Observatory have been unified. Identical values of U.T. 1, U.T. 2, A 1, as well as co-ordinates of the pole based on data furnished by the Rapid Latitude Service are distributed weekly.

Hamburg. Hydrographisches Institut. The time and latitude service is carried on by means of a PZT 250/3750 mm, which has been in use since September 1957. The programme includes 119 stars and can be observed without any changes until 1970. From January 1962 an improved star catalogue (System 1962) has been used, the star places being derived from observations made with the PZT from September 1957 to June 1961. From April 1963 the main timekeeper is a newly developed transistored quartz clock with a lens-crystal by Rhode and Schwarz. Radio-signals on short waves have been transmitted since 21 March 1962 by DAM at Elmshorn near Hamburg, the daily fluctuations being of the order of $\pm$ 0·1 ms.

Japan. Time observations in Japan have been continuously made at the Tokyo Astronomical Observatory, Mitaka, and at the International Latitude Observatory, Mizusawa, both with PZT's. The times observed are kept at the observatories, respectively by a pair of the Essen ring type quartz clocks, and other auxiliary ones.

The latest revision of star places of the PZT stars was made in 1959 at Tokyo and in 1962 at Mizusawa. The revised PZT star catalogue of Mizusawa was compared with the Washington PZT star catalogue, Boss's General Catalogue and FK3.

A Danjon-type astrolabe will be installed in 1963 at Mizusawa for time and latitude observations.

The time signals JJY on the standard frequency transmissions have been emitted at the Radio Research Laboratories under the plan for the co-ordination of world-wide synchronism, since 1961 September.

The frequencies of JJY have since then been kept within a limit of $\pm$ 5 parts in 10^{10} of the nominal ones, by use of an ammonia maser-type frequency standard operated at the Laboratories.

The time signals JAS 22 on 16170 kHz have been emitted at $12^h\ 30^m$ U.T. exclusively for

Europe from Oyama, a station of the KDD Co., being monitored by the Tokyo Astronomical Observatory.

ΔT = E.T.-U.T. was determined for the period of eight years from 1952 to 1959, and further for the years of 1961 and 1962, both from the data of the lunar observations made with the transit circle at Tokyo. The annual mean values for the successive eight years $+29^{s}.30$, $+30^{s}.89$, $+31^{s}.14$, $+30^{s}.74$, $+30^{s}.89$ and $+32^{s}.09$ with the mean error of $\pm 0^{s}.33$ in average, and for the other two years as $+32^{s}.56 \pm 0^{s}.25$ and $+32^{s}.76 \pm 0^{s}.21$. The value for 1960 is in course of calculation.

The rate of rotation of the Earth during the period of 1956 to 1962 inclusive was investigated. The times determined at eleven observatories were compared with that of the atomic time system. In this research, the seasonal variation in the rate of Earth's rotation was obtained, and it was noted that the existence of a periodic change of about 5·5 years seems plausible.

The effect of the interaction between the core and the mantle of the Earth on the rotation of the Earth was studied theoretically. It was shown that this can account for such various phenomena, concerning the rotation of the Earth, as the variabilities in the period and amplitude of the Chandler component of the polar motion, and the discrepancies of the observed phases and amplitudes of the fortnightly and semi-annual components of the nutational motion from the ephemerides which are calculated on the assumption of the rigid Earth.

An abrupt change in the rate of rotation of the Earth which occurred around the beginning of 1963 was discovered. The abrupt change was determined from the data of the Tokyo PZT observations compared with the atomic time, as the increase of rate of about 5 parts in 10^{9}. It was shown that this amount could be ascribed to an abnormal world-wide meteorological event in January and February, 1963, i.e. the extraordinary distribution of air mass in the northern hemisphere, which caused a decrease of the angular momentum of the westerly wind on a world-wide scale and consequently the increase of rate of the Earth's rotation.

The standard frequency signals on v.l.f., which are emitted at GBR and NBA stations, have been received daily at the Tokyo Astronomical Observatory since 1961 for comparison with the frequency of the standard quartz clock of the Observatory. From the comparison of these data with the corresponding ones obtained at the four laboratories, NBS (Washington), LSRH (Neuchâtel), NPL (London) and NRC (Ottawa), where the above signals have also been received, the accuracy of frequency comparison on v.l.f., when the comparisons were made at an interval of 24 hours, was found to be $\pm$ 5 parts in 10^{11} for a single comparison for each laboratory. The best result in the stability of frequency standards was $\pm$ 3 parts in 10^{11} for NBS (Washington) and LSRH (Neuchâtel), while $\pm$ 7 parts in 10^{11} for the quartz oscillator of Tokyo.

Meanwhile, an abrupt change in phase of NBA signals was observed at Tokyo just after the high-altitude nuclear explosion test made at Johnstone Island at 9^{h} U.T. on 1962 July 7. It caused the abrupt increase in the transit time of signals, which attained about 30 micro-seconds, corresponding to the amplitude of the usual diurnal variations of transit time for ordinary days as received in Tokyo.

Johannesburg. In accordance with the scheme for international co-ordination of radio time and standard frequency stations, the time signals transmitted by station ZUO were kept within ± 1 millisecond of those of WWV as from 1 January 1961.

Continuous frequency comparisons employing v.l.f. transmissions were commenced in 1962, and as from 1962 November the ZUO frequency has been kept within ± 5 parts in 10^{10} of that of GBR and NBA.

Neuchâtel. Time determinations have been carried out regularly with the PZT (located at the Observatory site) and with the Danjon astrolabe (at the Vue-des-Alpes station). The observations with the latter were interrupted from 1962 December to 1963 September.

The frequency of the standard frequency and time signal transmitter HBN is maintained constant by means of a caesium and a thallium beam frequency standards; the latter has been built during 1962 at the Observatory, the former being located at the Laboratoire Suisse de Recherches Horlogères, Neuchâtel.

All results, i.e. astronomical time determinations, v.l.f. frequency comparisons and reception times of time signals are published in the monthly bulletins of the Observatory.

Ottawa. Dominion Observatory. May 1963 marks the completion of three years operation of the Ottawa PZT in its new location. Completely automatic operation with protection against precipitation and light accompanies dusk to dawn observing. The caesium resonator of the National Research Council continues to serve as a frequency monitor, and has been augmented by rubidium and caesium standards of commercial design located at the observatory and other government laboratories.

Time signals from WWV, NSS, NBA and GBR are monitored daily and prepared for general distribution together with PZT observations on monthly summary statements.

A Markowitz Moon camera continues to be operated using the 15-inch equatorial. From 24 plates secured on seven nights during 1962, $\Delta T = \text{E.T.} - \text{U.T.}2$ was computed to be 31·5 seconds.

Paris. Centre National d'Etudes des Télécommunications (CNET). L'Atomichron continue à fonctionner régulièrement; sa comparaison aux étalons de fréquence du CNET et aux horloges du BIH a été rendue automatique. Les études d'autres étalons atomiques à jet, à pompage optique, ou à maser, se poursuivent. Les mesures continues de phase des émetteurs à ondes myriamétriques, pour la comparaison internationale des étalons atomiques et pour l'étude de la durée de trajet, ont été étendues aux nouveaux émetteurs; elles s'appliquent maintenant à GBR, NAA, NBA, NPG/NLK, NPM et NSS.

Prague. Observations for time were continued with the transit instruments at Prague, Pecný (near Ondřejov), Bratislava and with the Nušl-Frič astrolabes at Prague and Pecný. Only two transit instruments at Prague and Pecný were used for the operational work of the Time Service. Time and frequency are transmitted by station OMA on 2·5 MHz and on 50 kHz, by OLB5 on 3170 kHz. Special signals have been emitted by station OLD2 to Japan on 18 985 kHz for the purpose of determining the travel time. The oscilloscope has been used for the reception of time signals.

A system was developed for a quartz oscillator frequency control of the station OMA, using a three loop servosystem controlling the phase, frequency and its rate in terms of a reference frequency derived from an atomic standard. This reference frequency is being tentatively derived from the GBR signal until the ammonia maser, being developed during 1963, comes into regular operation.

The changes in the speed of rotation of the Earth have been studied.

San Fernando. Observations were continued with two small transit instruments by Bamberg and Repsold. Three quartz oscillators are used for time keeping and a fourth, located outside, is directly connected with the observatory. A cathode oscilloscope is utilized for the reception of radio signals.

Teddington. National Physical Laboratory (NPL). The caesium beam standard having a precision of ± 1 part in 10^{11} and an estimated definitive accuracy of ± 3 parts in 10^{11} has been in continuous use since the beginning of 1960. It has been compared regularly with standards in the U.S.A., Canada, France and Switzerland by means of v.l.f. transmissions. Since May 1961 the frequency of the MSF service of standard transmissions and of the GBR transmitter have been maintained within ± 2 parts in 10^{10} of their nominal values. Work is in progress on gas cell atomic standards and on a hydrogen maser. The times of emission of the timing pulses superimposed on the standard frequency transmissions in the U.K. and the

U.S.A. have been brought into close agreement. This synchronisation is limited to about 1 ms by ionospheric effects. The NPL suggested that the two-way transmission of pulses via Telstar would overcome this difficulty and an experiment carried out in collaboration with the U.S. Naval Observatory showed that synchronization to $\pm$ 1μs could be achieved by this method.

Uccle. Les observations sont faites d'une manière courante à trois instruments: Bamberg-Askania Ap 90, Askania Ap 70, un Astrolabe à prisme impersonnel Danjon.

On utilise depuis 1963 un chronographe d'un type nouveau qui enregistre sur bande perforée, au millième de seconde près, les tops du micromètre impersonnel d'un instrument des passages. La bande est ensuite passée à l'ordinateur électronique IBM 1620 qui après un calcul extrêmement rapide fournit directement la correction d'horloge. Ce chronographe électronique entièrement transistorisé a été construit par les établissement ATEA d'Anvers.

La parabole d'interpolation de l'heure, portant sur plusieurs mois d'observation est calculée entièrement en tenant compte des poids de chaque observation au moyen de l'ordinateur IBM qui, outre les valeurs interpolées, fournit les écarts de chaque observation à la courbe d'interpolation la plus probable.

Une nouvelle horloge à quartz primaire, entièrement transistorisée, de la firme Rhode et Schwartz est entrée en service à Uccle durant l'année 1963, la précision de son fonctionnement est remarquable.

U.S.S.R. 13 time services have been in operation. Radio time signals are transmitted on short waves by three stations (RWM, RBT, RPT) and on long waves by two stations (RES, ROR). Since 1963 the transmissions are given in uniform atomic time.

Reception of the time signals is made at all the time services by the oscillographic method. The mean square error of reception on both short and long waves is, on the average, 0·1 to 0·2 ms (**10**).

For the determination of time the following were used: eight transit instruments with photo-electric registration, nine transit instruments with impersonal micrometers, five astrolabes. Especially high precision was obtained with the new photo-electric transit instrument at Pulkovo; the mean square error of the determination of time, as reduced to the equator, in 1961 was $\pm$ 0·0038 sec (**10**). The investigations of these determinations (**12, 13**), were useful for examining the causes of some important sources of error in astronomical observations, such as refraction inside the pavilion.

The compilation of individual catalogues of right ascensions of the stars for the separate time services into a general list was in progress.

D. Bélotserkovsky detected, from the observations of 1955–62, a term in the rotation of the Earth with a period of a quarter of a year.

N. Pavlov and G. Staritsyn found a relation between changes of micro-climate and variations of the Earth's rotation (**8**) and also a similar trend of seasonal errors for closely located time services (**11**).

N. Pavlov and A. Tshelombitko detected a very short period in the speed of the Earth's rotation of about one month from a comparison of results at Pulkovo and Zi-Ka-Wei in 1962.

Definitive times of the emitted radio signals were regularly computed and published, using the results of the time services of the U.S.S.R., Czechoslovakia, German Democratic Republic and China. Since 1961 these have been given in the system of U.T.2. The Bulletins of standard times contain the data for 63 daily transmissions, 39 of which are from the Soviet Union.

Warsaw. Technical University. Regular time determinations are being continued. Observations are made with a transit instrument and referred to the quartz clocks of the Polish Bureau of Standards. A printing chronograph is under examination. Since 1962 January 1, till 1963

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June 1, about 4000 transits were observed. Two studies were published: on the analysis of time determinations at the Observatory in 1958 and 1959, and on relative personal equations.

Washington. U.S. Naval Observatory. The determination of Universal, Ephemeris, and Atomic times was continued at Washington, D.C. and Richmond, Florida, utilizing the PZT, the dual-rate Moon camera, and atomic clocks.

The time transmission of six U.S. Naval radio stations and the frequency of five v.l.f. stations were controlled, as were the time pulses of the U.S. East Coast Loran-C chain of the U.S. Coast Guard. The frequency of the control oscillators at the v.l.f. stations is maintained constant to about 5×10^{-11} and at the Loran-C stations to about 1×10^{-11}.

Studies were made of the stabilities of high-precision oscillators, quartz-crystal and atomic. The reference system is atomic time, A1, based on the caesium oscillators located in eight laboratories. The 2·5 MHz quartz crystal of the type developed at the Bell Telephone Laboratories shows high stability in various oscillators. Commercial guarantees are about 5×10^{-11} daily drift rate (ddr). However, 1 or 2×10^{-11} ddr has been found for several oscillators tested. KWS-9, installed at the Naval Observatory in May 1961, has a ddr of 2×10^{-12}. Rubidium gas cells tested were stable to about 1×10^{-11} for several months.

The Naval Observatory participated in the determination of the frequency of the hydrogen maser; a stability of about 1×10^{-12} is indicated.

The flashing light, geodetic satellite, ANNA, is observed at Washington and Richmond with PC-1000 cameras.

Telstar was used for microsecond clock synchronization experiments.

Studies of the speed of rotation of the Earth continued. Observations made with the PZT's since 1955 show that U.T.2 − A1 can be well represented by segments of parabolic arcs with common tangents. This indicates that sudden changes occur in acceleration but not in speed. A change from a practically constant deceleration to acceleration occurred about 1957 September and an opposite change about 1962 January.

RAPPORT SUR L'ACTIVITÉ DU BUREAU INTERNATIONAL DE L'HEURE (BIH) POUR LA PÉRIODE 1960–1963

(préparé par M. Stoyko, Chef des Services)

L'activité du Bureau International de l'Heure (BIH) ne s'est pas ralentie après la fin de l'Année Géophysique Internationale (AGI) et de la Coopération Internationale Géophysique (CIG).

La comparaison des horloges à quartz entre elles et avec des étalons atomiques a été faite deux fois par jour avec la précision de la micro-seconde. La réception des signaux horaires a été faite sur l'oscillographe cathodique et les résultats ont été enregistrés sur les compteurs électroniques à 1/100 000 ème de seconde. Les observations astronomiques ont été faites en utilisant deux astrolabes impersonnels de Danjon (modèle OPL) et la lunette des passages Bouty.

On a commandé sept fois par jour des émissions de signaux horaires sur différentes longueurs d'onde. Le nombre normal des signaux horaires enregistrés quotidiennement au BIH a été de 130.

Le *Bulletin Horaire* a paru régulièrement en deux séries. Il a donné dans les séries 5 et 6 les heures demi-définitives de toutes les émissions reçues au BIH, les résultats des observations astronomiques et les corrections des horloges à quartz ainsi que les corrections des étalons atomiques (temps intégré). Pour la période de 1955.5 à 1956.7 on a publié le temps atomique intégré d'après l'étalon de Teddington, de 1956.7 à 1957.0 d'après 3 étalons, et en 1958, 1959 et 1960 d'après 5 étalons atomiques. Depuis le 1er Janvier 1961, on publie le temps atomique

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intégré d'après les 9 étalons atomiques. L'écart moyen systématique de fréquence d'un étalon atomique par rapport à la moyenne de 9 étalons est égal à 8×10^{-11}. L'écart de l'heure intégré entre la moyenne de 5 et 9 étalons atomiques au bout de la période de 29 mois est égal à $0^s.0013$. Cela nous donne l'écart journalier égal à $0^s.000\,001\,5$, ce qui correspond à $1{\cdot}7 \times 10^{-11}$ en fréquence.

En choisissant 6 meilleurs étalons atomiques, on trouve pour l'écart moyen de fréquence d'un étalon $2{\cdot}3 \times 10^{-11}$. Cela nous donne un écart à 0·72 ms au bout d'une année. La moyenne de 6 meilleurs étalons donnera l'erreur de temps intégré au bout d'une année à 0·3 ms.

Le *Bulletin Horaire*, Série G, publie principalement les heures définitives du BIH et les réductions des heures conclues de chaque observatoire (Service horaire) à l'Observatoire moyen. Pour le calcul de l'heure définitive, on a utilisé la réception de plus de 700 émissions journalières dans 40 services horaires. On a publié en 1960, en moyenne, les heures définitives de 250 émissions journalières.

Etant donné l'augmentation de la précision des émissions de signaux horaires et de fréquences-étalon, les heures de ces émissions varient linéairement avec le temps. En tenant compte de cette régularité d'émission de signaux, on a seulement publié en 1962 les heures définitives pour les 150 émissions journalières.

On publie, de plus, dans la Série G, la correction définitive de l'étalon moyen atomique (moyenne de 9 étalons à césium). En utilisant les résultats du *Bulletin Horaire*, on peut conclure les heures des signaux horaires, ainsi que les corrections des heures astronomiques de chaque Observatoire en fonction du temps atomique uniforme.

Actuellement, dans les services horaires, on utilise le temps universel uniforme provisoire (T.U.2). Pour avoir ce temps, on a besoin de calculer la variation saisonnière de la rotation de la Terre et les coordonnées du pôle instantané. La variation saisonnière de la rotation de la Terre est calculée par rapport au temps atomique et à l'Observatoire moyen du BIH. De 1956 à 1961 inclus, on a utilisé une même formule pour la variation saisonnière de la rotation de la Terre:

$$\Delta S = +\ 0^s.022 \sin 2\pi t - 0^s.017 \cos 2\pi t - 0^s.007 \sin 4\pi t + 0^s.006 \cos 4\pi t.$$

A partir de l'année 1962, on a utilisé la nouvelle formule. Cette formule a été calculée en rapportant tous les résultats horaires à partir de l'année 1955 à l'ensemble des étalons atomiques et au pôle moyen de l'époque. De plus, on a tenu compte du catalogue FK4 à partir du 1er Janvier 1962. La nouvelle formule est la suivante:

$$\Delta S = +0^s.022 \sin 2\pi t - 0^s.012 \cos 2\pi t - 0^s.006 \sin 4\pi t + 0^s.007 \cos 4\pi t.$$

Les coordonnées du pôle instantané sont calculées d'aprés le Service International Rapide des Latitudes de Paris (SIR). Ces résultats sont publiés dans les *Circulaires* du BIH, et dans le *Bulletin* on publie les corrections correspondantes de l'heure pour les services horaires participant au BIH. En tenant compte des décisions de l'Union Radio-Scientifique Internationale (Londres, 1960), de la Commission Internationale de l'Heure (Berkeley, 1961) et du Comité Consultatif International des Radiocommunications (Genève, 1963), le BIH calcule pour les émissions des fréquences-étalon le décalage à utiliser chaque année, après avoir consulté les observatoires intéressés, de façon à maintenir les signaux horaires en concordance étroite avec T.U. 2. Ce décalage est exprimée dans une échelle telle que la fréquence de l'étalon à césium y ait une valeur:

$$f(\mathrm{Cs}) = 9\,192\,631\,770 \text{ Hz}$$

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RAPPORT SUR LES ÉTUDES SPÉCIALES SE RAPPORTANT AUX SERVICES DE L'HEURE ET DES LATITUDES

(préparé par M. et Mme Stoyko)

1. *L'Année Géophysique Internationale et la Coopération Internationale Géophysique*

(*a*) *Longitudes.*

A la 3ème opération des longitudes mondiales, ont participé, 53 stations dont 41 continuent à travailler comme services permanents. Pour la détermination astronomique de l'heure, les stations participantes ont disposé 98 instruments astronomiques.

Le nombre de réceptions de signaux horaires a atteint pendant cette opération une valeur d'environ 1 000 000 et le nombre de séries des observations astronomiques pour la détermination de l'heure a atteint 40 000. Nous avons calculé les longitudes de toutes les stations en utilisant le pôle moyen de l'époque d'après la décision de l'UAI à Moscou en 1958.

Les erreurs moyennes de détermination d'une longitude sont égales respectivement à $0^s.027$ (1926), $0^s.017$ (1933) et $0^s.003$ (1957–59).

La discussion des résultats de l'Année Géophysique Internationale se poursuit. Nous continuons la discussion des résultats de longitudes par instrument et observateur, la détermination de la vitesse apparente de propagation des ondes radioélectriques, l'amélioration du catalogue d'étoiles observées, etc.

(*b*) *Latitudes.*

Comme nous avons reçu aussi les résultats des observations de latitude pendant l'AGI et la CIG, nous avons utilisé ces résultats pour déterminer les latitudes moyennes des stations, ainsi que les coordonnées du pôle instantané par rapport au pôle moyen de l'époque.

Nous avons pu utiliser les résultats des observations astronomiques de latitude dans 37 stations qui ont travaillé avec 45 instruments de types différents: 12 astrolabes de Danjon, 9 lunettes zénithales photographiques, 23 lunettes zénithales de types différents, dont ZTL 180 et 1 lunette photographique flottante.

Nous avons utilisé dans la majorité des cas la méthode d'Orlov pour le calcul de latitudes moyennes. Nous avons amélioré le catalogue pour une partie des stations étudiées.

II. *Variation séculaire du mouvement du pôle*

En utilisant les résultats des observations des stations de l'hémisphère Nord du Service International des Latitudes (SIL), nous avons recalculé les coordonnées du pôle instantané dans un même système uniforme pour la période de 1900 à 1962. Nous avons calculé, en utilisant ces coordonnées, la variation séculaire du pôle instantané et nous avons trouvé pour la vitesse moyenne annuelle des valeurs oscillant entre $0''\cdot0027$ et $0''\cdot0037$ et pour la direction oscillant entre 63° et 68°W suivant les différentes combinaisons des stations du SIL.

III. *Service International Rapide de Latitudes* (*SIR*)

On a chargé le BIH d'interpoler et d'extrapoler les coordonnées du pôle instantané en utilisant, dans ce but, les valeurs fournies par le Bureau Central du Service International des Latitudes (SIL).

Le SIL envoyait au BIH les coordonnées du pôle instantané avec un grand retard et même, pendant certaines périodes, ne les envoyait pas du tout.

A cause de cela nous avons repris le travail du SIR pour donner au BIH les coordonnées du pôle instantané aux dates fixes. Au début de 1956, 4 stations seulement ont participé à ce service. Vers la fin de la même année, on comptait déjà 9 stations participantes. Ce nombre a augmenté progressivement jusqu' à 10 (1957), 11 (1958), 16 (1959), 17 (1960), 21 (1961), 25 (1962) et 27 (1963) services participants. Nous espérons qu'on aura bientôt 30 stations de latitudes participant au SIR de Paris.

IV. *Révision des longitudes conventionnelles*

Nous avons recalculé toutes les longitudes conventionnelles des services horaires permanents qu'on a pu utiliser dans le calcul des heures T.U.2 à partir du 1er Janvier 1962 simultanément avec l'introduction du nouveau catalogue fondamental FK 4. Ce calcul a été basé sur les principles suivants:

(1°) Le méridien origine adopté universellement est le méridien de Greenwich (ancien emplacement de l'Observatoire de Greenwich);

(2°) Les longitudes instantanées observées sont ramenées à leurs valeurs moyennes en utilisant les coordonnées du pôle instantané par rapport au pôle moyen de l'époque, d'après les décisions de Moscou (1958) et de Berkeley (1961).

En tenant compte de ces principes, nous avons recalculé les longitudes conventionnelles de 41 services participant au travail du BIH. Ces résultats sont publiés dans le *Bulletin Horaire*, Série 5, no. 16, 1961, p. 361.

V. *Mouvement du pôle d'après les services horaires*

Madame A. Stoyko a montré (**14**) qu'on peut déterminer les coordonnées du pôle instantané d'après les résultats des services horaires. Elle a utilisé les résultats de 14 services horaires à partir de l'année 1940. Elle a trouvé une bonne concordance avec les coordonnées du pôle instantané déterminées par le SIL après avoir éliminé le terme saisonnier qui restait le même pour toute la période étudiée.

Elle a calculé d'après cette méthode les coordonnées du pôle instantané jusqu'à l'année 1959 (**15**).

Pour déterminer les coordonnées du pôle instantané d'après les services horaires, il faut résoudre le problème de l'élimination du terme saisonnier indépendant du mouvement du pôle qui correspond au terme '*z*' des stations de latitude. Ce problème n'est pas encore résolu et on a besoin de déterminer empiriquement les variations saisonnières non polaires.

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President of the Commission

BIBLIOGRAPHY

1. Fedčenko, Ph. M. An astronomical clock with electromagnetic excitation of the pendulum motion. *Trudy Inst. Kom. Standart. Mer i izmer. Priborov SSSR Moskva.* no. 58 (118), 92, 1962.

2. Guinot, B., Débarbat, S., Krieger-Fiel, J. Catalogue des positions de 571 Etoiles du FK3 et du FK3 Supp. observées aux astrolabes A. Danjon, type OPL, de l'Observatoire de Paris, *Bull. Astr.*, **23**, 307, 1961.

3. Pavlov, N. N. A preliminary catalogue of right ascensions of stars observed with the photo-electric transit instrument at Pulkovo during the IGY. *Izv. glav. astr. Obs. Pulkove*, **22**, no. 168, 2, 1961.

4. Danjon, A. Sur la variation continue de la rotation de la Terre, *C.R. Acad. Sci. Paris*, **254**, 2479–2482, 1962.

5. Danjon, A. La rotation de la Terre et le Soleil calme. *C.R. Acad. Sci. Paris*, **254**, 3058–3061, 1962.

6. Rochester, M. G. Geomagnetic westward drift and irregularities in the Earth's rotation. *Phil. Trans. Ser. A. Math. and Phys. Sci.*, **252**, no. 1018, 531, 1960.
7. Belotserkovsky, D. Y. On short-period variations of velocity of the Earth's axial rotation. *Report to the XIIIth Assembly of IUGG*, 1963.
8. Pavlov, N. N., Staritsyn, G. V. On variations of the seasonal annual term of the Earth's axial rotation during 1960 and 1961. *Astr. Zu.*, **39**, 123, 1962.
9. Pavlov, N. N., Tshelombitko, A. P. On the short-period variations of the velocity of the Earth's axial rotation. *Astr. Cirk. Akad. Nauk U.S.S.R.*, 1963.
10. Belotserskovsky, D. Y. The standard time for the mean moments of transmission of radio-signals, April 1962, February 1963. *Trudy Inst. Kom. Standart., Mer i izmer. Priborov SSSR* (*Moskva*) no. 58 (118), 65, 1962.
11. Pavlov, N. N., Staritsyn, G. V. On the variations of the rate of the Earth's axial rotation during the IGY and IGC. *Astr. Zu.*, **39**, 123, 1962.
12. Pavlov, N. N. On a rational type of astronomical instrument for the determination of time. *Trudy* 15. *Astromet. Konf. SSSR Moskva-Leningrad*, 1963, p. 246.
13. Chin-Chun-lan A study of the error of a night and the effect of the wind from observations with the Pulkovo new transit instrument. *Izv. glav. astr. Obs. Pulkove*, **23**, no. 171, 41, 1962.
14. Stoyko, A. *C.R. Acad. Sci. Paris*, **242**, 2298, 1956.
15. Stoyko, A. *Ann. Franç. Chronom.*, **15**, 165, 1961.