31. COMMISSION DE L'HEURE

Report of Meetings

PRESIDENT: H. M. Smith.
SECRETARY: R. G. Hall.
INTERPRETER: J. Bonanomi.

First session, 23 August 1967

The loss was noted of two distinguished members of the Commission; A. Danjon and F. de la Puente.

The President reported that the following people were proposed for membership in the Commission: G.M.R. Winkler, E. Proverbio, and G. Hemmleb. All were approved by the members.

The President reported that the following two names were proposed as consulting members of the Commission: U. Adelsberger and J. Terrien. The transfer of L. Essen from member to consulting member was under discussion. This was approved.

The President asked for comments on the *Draft Report*. There being none, the *Report* was approved.

The Director of the B.I.H. reported on the activities of the B.I.H. which are given in the *Draft Report*. *H. M. Smith*, President of the Directing Board of the B.I.H., reported that it is not a function of the B.I.H. to report or note legal times of the various Governments. There was general agreement that this was the case. The report of the Director of the B.I.H. was approved with thanks to B. Guinot.

Resolutions that had been submitted to the President were then considered.

A resolution from the French Commission of Geodesy and Geophysics concerning the form of the emission of time signals from HBG, Switzerland, was taken note of by the Commission. The resolution reads:

> Le Comité National Français de Géodésie et Géophysique a pris connaissance avec grand intérêt du programme d'émissions de signaux horaires continus diffusés par l'émetteur suisse HBG sous contrôle de l'Observatoire Cantonal de Neuchâtel. La poursuite de ces émissions serait de la plus grande importance tant pour les stations séismologiques fixes que pour les travaux de séismologie expérimentale. Le Comité souhaite que des marques d'identification de l'heure soient ajoutées au programme d'émission.

Resolutions on the sign convention of time and frequency differences were submitted by *G. M. R. Winkler* and *B. Guinot*. After some discussion a working group of B. Guinot, G.M.R. Winkler, W. Markowitz, and L. Essen was set up to draft a single resolution incorporating the points raised.

A resolution on the need for carrying atomic clocks, in aircraft, to synchronize clocks world-wide was submitted by *N. Stoyko*. Discussions on this resolution were postponed, and the subject was dealt with at a Joint Meeting of Commissions 4 and 31. (Resolution 4.)

Second Session, 28 August 1967

At an earlier joint meeting (26 August 1967) of Commissions 4 and 31, it was proposed that the following officers of Commission 31 be nominated: President, F. Zagar; Vice President, G.M.R. Winkler; Organizing Committee, D. Belocerkovskij, J. Bonanomi, H. Enslin, W. Markowitz, H.M. Smith, and M. Torao. All votes were in favour of this.

After extended discussion a proposal by *G. M. R. Winkler* and *R. G. Hall* that the Commission should recognize Modified Julian Day Numbers was rejected. It was proposed that this be studied further for future meetings.

Resolution 1 on the Julian Day Number to be used for reporting 5 and 10-day values was submitted by *B. Guinot* and approved unanimously.

L. Essen reported on the uncertainties of Atomic Standards and reported the accuracies, the advantages, and disadvantages of the various types. He suggested direct tests of relativity effects on atomic standards.

J. Bonanomi reported on comparisons of national standards. He referred to flying clock experiments which facilitate time intercomparisons between standards, and frequency comparisons between different types of atomic standards located at the various laboratories. He finds all laboratory models of atomic standards to agree to at least 3×10^{-12}. He reported various determinations of frequency of Hydrogen Masers.

Discussion on the above two papers was postponed as the meeting was adjourned.

Third Session, 29 August 1967

The meeting was opened by the President who read Resolution 2 on the sign conventions in expressing time and frequency differences, which had been drafted by the working group. After some discussion the resolution was passed unanimously.

R. G. Hall presented the current results of the U.S. Naval Observatory Moon-position program. Preliminary results of ET0-UT2, corrected for irregularities of the limb of the Moon, were presented as determined from over 5000 plates taken at 17 observatories located internationally. It was pointed out by *W. Markowitz* that the use of artificial satellites has probably supplanted the use of the dual-rate Moon-position camera for geodetic positions.

W. Markowitz presented the progress during the last three years in synchronizing clocks by means of VLF, Omega, Loran-C, artificial satellites, and by flying clocks, both by landing and by automatic means. Certain specialized methods of synchronization using the Moon and meteor bursts as reflectors were mentioned.

S. Puskhin presented data on the use of atomic standards in the USSR and gave the calculated frequency differences between the USSR standard (Hydrogen Maser) and standards in France, the United Kingdom, and the USA. These were 1 or 2 parts in 10^{11}. The comparison was made via the VLF stations GBR and NBA.

In a general discussion of caesium beam atomic standards it was pointed out by *H.M. Smith* that the short beam standards of the Hewlett Packard Company are independently made and adjusted and hence can be averaged to obtain a mean frequency. *W. Markowitz* and *J. Bonanomi* pointed out that these modern short beam tubes were as accurate as the old long beam tubes. *L. Essen* suggested that further work is needed on new long beam tubes to increase the accuracy of caesium standards.

The meeting adjourned.

Fourth Session, 29 August 1967

The President opened the session by introducing *M. Cohen* from Commission 40 (Radio Astronomy) who discussed the use of long base line interferometer measures of radio sources in timekeeping. Present systems in use allow relative time measurements to 1 microsecond. It is hoped that future systems would give a better determination of the rotation of the Earth than can be obtained with optical equipment. In the discussion it was pointed out that this equipment is very expensive and that different air-mass paths of the different stations would introduce systematic effects, perhaps larger than for optical equipment.

H. Torao presented results of many careful experiments on the propagation of radio waves. He pointed out that it would be desirable for all to use the same velocities of propagation for the determination of the travel time of time signals.

F. Zagar reported on measurement techniques of radio time signal comparisons. It is necessary to calibrate very carefully the delay introduced by the receiving equipment.

After thanks to the interpreter and secretary, the President closed the meeting.

Resolutions adopted by Commission 31:

(1) La Commission 31 de l'Union Astronomique Internationale recommande que les données à l'usage des services horaires ayant le temps universel comme argument
(*a*) soient rapportées, dans la mesure du possible, à 0^hTU,
(*b*) si elles sont tabulées de 5 en 5 jours, soient rapportées aux dates juliennes se terminant par 4,5 et 9,5,
(*c*) si elles sont tabulées de 10 en 10 jours, soient rapportées aux dates juliennes se terminant par 9,5.

(2) 1. To avoid any possible error in the sign of a difference in time between clocks, or in frequencies between oscillators, algebraic quantities should be given.
2. The following definitions and conventions may be used in conjunction with the algebraic expressions:
2.1. Let A denote either a clock or its reading; similarly for B. At some instant let

$$A - B = D \tag{1}$$

Then D is positive if reading A is greater than reading B, and D is negative if reading A is smaller than B.
2.2 Let the frequency of an oscillator a be f_a; similarly for oscillator b and frequency f_b. Let

$$f_a - f_b = \Delta f. \tag{2}$$

Then a is *higher in frequency* than b if Δf is positive. The frequency of a is *lower* if Δf is negative.
2.3 The *deviation from nominal* of an oscillator a is defined as

$$d = f_a - f_n \tag{3}$$

where f_n is the nominal frequency. The frequencies f_a and f_n are expressed in terms of the second equal to 9192631770 periods of caesium radiation.
2.4. The *fractional difference in frequency* between two oscillators H and K, with respective frequencies f_H and f_K, which have the same nominal frequency, f_n, is computed from

$$S = (f_H - f_K)/f_n \tag{4}$$

and is conventionally designated

$$H - K = S, \tag{5}$$

The same sign conventions apply as in 2.2.
2.5. A time comparison between a clock and a time signal should be expressed as in section 2.1.
2.6. A frequency comparison between an oscillator and a radio frequency emission should be expressed as in sections 2.2, 2.3, and 2.4.

BUREAU INTERNATIONAL DE L'HEURE. SUPPLEMENTARY REPORT

DIRECT REDUCTION OF INDIVIDUAL MEASURES OF TIME AND LATITUDE

Principles

As it could be easily foreseen from the new transmission forms of data to the BIH and the IPMS, our aim was to compute directly the coordinates of the pole x, y and UT1 from the individual values (for one group or one night) of the latitude ϕ and UT0.

This computation is only feasible if it is possible to take into account the systematic errors attached to each instrument. By applying the method described in the 'Draft Reports' we reduced

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the data for every 0·05 year for 1964, 1965 and 1966. It appeared that the systematic errors are stable enough to allow a one-year extrapolation.

Methods of Reduction

We are using the following procedure:

(I) Reduction for every 0·05 year by use of conventional system of initial latitudes, longitudes and weights which realise the 'mean observatory' (as explained in the 'Draft Report'). Every instrument is treated independently (80 instruments; among them 21 are measuring simultaneously time and latitude).

(II) Analysis of the residuals r of ϕ and UT0. These residuals are represented by the formula.

$$r = a + b \sin 2\pi t + c \cos 2\pi t + d \sin 4\pi t + e \cos 4\pi t \qquad (1)$$

(t in Besselian years)

(III) Reduction for every 5 day interval, starting from the individual values of ϕ and UT0, corrected according to formula (1). As the corrected values are statistically equivalent, their repartition among the various observatories does not matter.

Reduction I maintains the 'mean observatory'. It is regularly made as soon as *all* the data are received.

Analysis II is to be made periodically (at least twice a year) to keep fresh values of the systematic corrections.

Reduction III must be used for the publication of the 'definitive time' (heure definitive) with very short delay. It allows, if necessary, not to wait the results of any observatory which could have been delayed.

Obtained Results

This method was started in January 1967, with the systematic corrections obtained for 1966. It was used actually for the publication of the 'definitive time', starting from June 1967 (circular D10).

Table 1 gives the unsmoothed values of the results for every five-day interval, with their standard errors. Every set of values for one five-day interval is independently obtained from the others.

It seems that the external agreement of the values of x, y and UT1 is not so good as it could be hoped from the standard errors (1ms in UT1, $0''.015$ in x and y). That could be due to the existence of short-period irregularities that we are studying.

Future computations of the BIH

For the present time, coordinates of the pole are computed from latitude measurements only and published earlier than UT1. Therefore we must correct the results of the above computation to bring them to the system of polar coordinates already published.

Starting from January 1968, UT1 and coordinates of the pole simultaneously obtained from reduction III will be published every month with a delay of the order of one month after the last observations (for instance, results of January will be published at the beginning of March.).

Smoothed values will be published as the current results. However, computed values of five-day intervals will be published later in an annual report.

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Tableau 1

Calcul des coordonnées du pôle (x, y) et de TU1-TUC par usage simultané des mesures individuelles de temps et de latitude

Date (0^h TU)		x	y	TU1-TUC en $0.^s0001$	écarts-type sur x	écarts-type sur y	écarts-type sur TU-TUC
1967 jan.	4	+ 0″.124	− 0″.044	0152	0″.016	0″.014	$0.^s0011$
	9	99	72	0172	20	17	15
	14	124	48	0158	17	16	12
	19	139	76	0204	13	14	10
	24	77	153	0216	19	19	15
	29	102	101	0171	17	15	12
fév.	3	127	109	0182	15	16	12
	8	109	67	0218	16	16	12
	13	72	95	0255	16	15	12
	18	81	55	0257	15	16	12
	23	85	91	0222	14	14	11
	28	64	45	0189	18	16	12
mars	5	67	88	0227	16	15	14
	10	53	64	0212	14	13	10
	15	71	50	0177	14	15	10
	20	48	78	0211	17	17	12
	25	19	68	0184	13	13	10
	30	41	48	0191	17	16	13
avr.	4	21	60	0148	17	15	12
	9	55	38	0159	14	14	11
	14	36	68	0166	12	12	9
	19	19	51	0142	12	13	10
	24	39	37	0094	17	15	12
	29	+ 28	25	0097	13	13	10
mai	4	− 15	47	0142	15	14	10
	9	+ 13	− 9	0065	13	15	12
	14	− 2	+ 28	0045	16	14	11
	19	+ 9	− 10	0095	14	14	11
	24	+ 28	− 42	0078	14	13	10
	29	+ 58	− 54	0095	18	16	13
juin	3	+ 13	− 34	0089	14	13	10
	8	18	− 27	0115	17	13	13
	13	22	− 17	0220	13	13	11
	18	2	− 50	0221	14	13	13
	23	60	+ 14	0211	14	13	11
	28	35	− 9	0273	14	13	11
juil.	3	29	− 25	0323	14	13	11
	8	25	− 32	0409	16	14	12
	13	46	+ 14	0425	16	14	12

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