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ADJUSTMENT OF RESULTS OF TIME OBSERVATIONS IN THE ASTRONOMIC-GEODETICAL OBSERVATORY OF THE WARSAW POLYTECHNIC AT JÓZEFOSŁAW

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WYRÓWNANIE REZULTATÓW OBSERWACJI CZASU W OBSERWATORIUM ASTRONOMICZNO-GEODEZYJNYM W JÓZEFOSŁAWIU

S t r e s z c z e n i e

Opisana jest metoda wyrównań okresowych obserwacji służby czasu, stosowana w Obserwatorium Astronomiczno-Geodezyjnym Politechniki Warszawskiej. Polega ona przede wszystkim na wykorzystaniu systemu sygnałów radiowych GBR jako zegara podstawowego, którego poprawki obserwowane podlegają wyrównaniu. Pozwala to na zwiększenie okresu z którego obserwacje mogą być wyrównywane jednocześnie.

W zakończeniu autor proponuje wprowadzenie jednolitego sposobu wyrównania we wszystkich obserwatoriach Międzynarodowej Służby Czasu, co ułatwiałoby porównanie wyników oraz ocenę ich dokładności.

A b s t r a c t

A description is given of the method of periodical adjustments, used by the time service of the Astronomic-Geodetical Observatory of the Warsaw Polytechnic at Józefosław. The method consists mainly in applying the system of GBR radio signals as standard clock whose correction observed are to be adjusted. This allows to increase the period from which the observations can be simultaneously adjusted. Concluding the author suggests the introduction of an uniform method of smoothing into the prac-

tice of all observatories of the International Time Service, for that would facilitate the comparision of results obtained and the evaluation of their accuracy.

The time service in the Astronomic-Geodetical Observatory of the Warsaw Polytechnic is performed with the aid of one transit instrument Zeiss (F = 1000 mm, D = 100 mm). The quartz clock Q_{11} of the National Bureau of Standards in Warsaw is used as the standard clock; it is connected with the observatory by a direct telephone line. As working clock the Rifler pendulum clock is applied for observations. Its rate is recorded continuously on the cylindrical chronograph in the National Bureau of Standards simultaneously with the quartz clock recording. For the registration of moments of stellar transits the band chronograph Favag is used. The climate conditions, the possibilities of the staff and the state of instrumentation allow for about 200 series of observations to be carried out annually. During a serene night one observer makes, as a rule, two observations (the evening series only). Unfortunately, the distribution of observations in time is usually unequal. During some months e.g. November and December it is difficult to make more then a few series of observations. During the remaining months of a year it often happens that after a period rich in observations there follows a break of 2-3 weeks consequent on atmospheric reasons or failure of the instrumentation. The Table 1 shows the number of observations made in 1961 and 1962.

Table 1

	1961	1962
I	16	11
II	7	8
III	0	9
IV	24	11
V	16	12
VI	25	33
VII	13	14
VIII	14	16
IX	33	10
X	42	23
XI	10	2
XII	3	5

In above mentioned conditions it was necessary to analyze thoroughly the question of the adjustment of results of observations from viewpoint of their utilization for the time service - in other words for calculating in a continous way the moments of reception of radio signals. It was advisable to adopt such a method of adjustment that would acommodate difficulties consequent on the disadvantageous distribution of observations, and would permit to make the best use of the comparatively small number of observations.

1. CHOICE OF THE METHOD

The value to be adjusted - the correction of the clock u - is variable in time according to a law that generally we do not know. Then we have the choice of two ways: a) the determination of that law simultaneously with the adjustment, this meaning the simultaneous determination of the form of the function and of its values; b) the adoption a p r i o r i a law of variablity, otherwise the assumption of the form of the function and the determination of its values only.

This problem appears in many empirical sciences and has been considered mor than once by many authors. Still there does not exist any universal recipe that can be applicable in every circumstances, exept the general principle stated by Whittaker and Robinson: "The problem is to combine all the materials of judgment - the observed values and the a p r i o r i considerations - in order to obtain the most probable values of u" [1].

The solution a) is answered by the graphical method of adjustment, used in several observatories, consisting in the freehand drawing of a curve passing through points plotted on the diagram. Yet, the method involves many imperfections. At first it is a source of new errors caused by the subjectivity of the designer: the errors charge all their value upon the determined points of the curve. Secondly - it does not give a chance to estimate the accuracy of the adjustment performed. At third - it is particularly unconvenient when the number of observations is small and when they are unequally distributed in time.

For, if there is not any a priori accepted low of variability of the searched function then in the periods when there are no observations there are no posibilities of drawing the curve. The application of the graphical method was justified in conditions when pendulum clocks or quartz clocks of a minor class had been used, it means then when it was very difficult to assume a priori a function approximating the actual behaviour of a clock. At present however the technique of time keeping has achieved a great progress getting at the same time a long way ahead of the technology of observation. While the accuracy of new types of clocks, of the order of 10^{-10}, secures the determination with the accuracy of $\pm 0^s{,}001$ of the more than three months time interval - the accuracy of observation is still of the orderr of $\pm 0^s{,}01$, and at the best a few miliseconds for single series of observation.

It is worth while to remark that the internal accuracy of particular series calculated according to the formula

$$m_u = \sqrt{\frac{[vv]}{n(n-2)} \cdot Q_{11}} ,$$

does not correspond to the actual accuracy of the determined time corrections. On the ground of material collected in the Józefosław Observatory the following list has been made up:

Table 2

Obs.	m_u	m_u'	$\lvert \Delta u \rvert$
D	$\pm 0^s{,}011$ 5	$\pm 0^s{,}028$ 4	$0^s{,}021$ 1
O	10 2	23 8	16 2
Z	11 5	24 1	17 6
C	11 9	29 9	26 9
L	16 9	35 6	17 6

The column "m_u" includes the average mean internal error of the series of five observers (the arithmetic mean of errors of several series). The column "m_u'" includes the mean error of the individual series calculated on the ground of deviations from the smoothed curve, according to the formula:

$$m_u = \sqrt{\frac{[\Sigma\Sigma]}{n-1}} .$$

In the column $|\Delta u|$ the means of the absolute values of differences u_1-u_2 are given, where u_1, u_2 are the corrections determined in two succesive series during the same evening by the same observer. The disparity between column 1 and columns 2 and 3 endorses the conclusion that the internal accuracy of an individual series does not adequately characterize its actual accuracy and leads to a statement that besides the very errors of the individual stellar transits other different factor varying in time have a great importance - i.e. atmospheric conditions, properties of the instrumentation or the disposition of the observer. Such a statement has to be taken into consideration when choosing the method of adjustment - to the effect that the smoothed curve shall not surrender excessively to individual points or groups of points what takes inevitably place in the graphical smoothing.

The above reasoning leads to conclusion that the application of the graphical method consisting in the freehand drawing of a curve is ill-founded if there exist only a possibility of applying the analytical method, on the principle given in the point b).

So it is necessary to define more precisely the conditions that the searched method of adjustment has to fulfill. The first condition is that the considered function has to be able to aproximate the actual rate of the clock with the accuracy of observation. Of course, the higher degree of the function and the shorter the considered period is, the higher the approximation capacity is obtained. However on the other part - the shorter the period to be adjusted, the greater is the influence of a disadvantageous distribution of observations. For example: a two weeks interruption of observations represents the half of a month period but only one sixth of a three months period. Analogically, the influence grows together with the increase of the degree of the adopted function. It is so because of the increasing number of unknowns and the greater probability of the occurrence of disadvantageous coefficients in the system of normal equations. Finally, the application of the longest possible period of adjustment is supported by the possibility of including then a great number of observations into the calculations.

So then we can bring out the searched criteria as following:

1^{o} The approcimating function has to be able to represent the actual course of a phenomenon with the accuracy of at least one order higher then the accuracy of observation.

2^{o} The function has to be of the degree lowest possible.

3^{o} The period taken for the adjustment has to be the longest possible.

Each of the three conditions mentioned above is opposed to two remaining ones. The determination of the proper optimum depends on the circumstances characteristic for the given particular case.

The nonfulfillment of conditions mentioned above can not only cause a decrease of the accuracy of adjustment but bluntly conduce to false results. At the first stage of work of the time service in the Józefosław Observatory the corrections for the mentioned quartz clock Q_{11} have been adjusted in the two-months periods applying the power polynomial of the 3-th degree. Yet as it came out, the polynomial could not always rightly represent the rate of the clock. Also the two-month period compared to the observational material available was too long to make possible the fulfillment of the condition 1^{o}, and too short to fulfill the condition 3^{o}. For that reason when particularly disadvantageous circumstances occured the distinctly

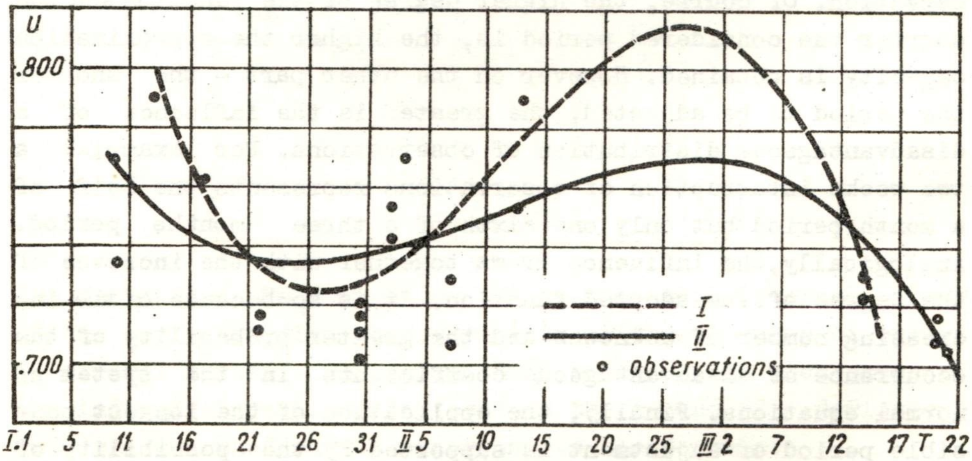

Fig. 1

wrong result has been obtained. This is shown in Fig. 1. The courve I is the result of the adjustment with a normal two-months period, the curve II is the result of adjustment of this period together with the added 4 observations from the week following after.

Generally, the more imperfect the observational material is (in the meaning of amount and distribution) the more the above conditions matter. Moreover, the better the standard clock is the easier it is to fulfill the conditions. So the deficiencies of the observational material can be recompensated to some extent by applying a clock of a high class.

In order to satisfy the above requirements the clock Q_{11} has been replaced in the process of adjustment with the system of radio signals GBR. As seen from the analysis of definitive moments of transmission of GBR signale [2], the standard clock of this station shows since April 1960 a regularity of the rate that allows for the application of a polynomial of the second degree for a four-months period with an error less than $\pm 0^{s}.002$ for an arbitrary point of a curve. So it had been decided that observations made during four months have to be used for one adjustment, the equation of error for one observation being

$$u_0 + \Delta T \cdot \omega_0 + \Delta^2 T \cdot \omega' = l + v , \qquad (1)$$

where ΔT is a time interval from the middle of the period considered. Only the two middle months of this four-months period are considered as definitively calculated. The extreme months, where the calculated curve is charged with a greater error, are again adjusted in the adjacent periods. The periods overlap as shown in the scheme (Fig. 2).

The connection of two adjacent two-months segments is being attained with the aid of a joining curve. In order to avoid the bend the first derivative of the joining curve has to be equal to the derivative of the smoothed curve in their contact points. I would be possible to apply as the curve fulfilling such a condition an adequately deformed sine-curve of a semi-period corresponding to the length of the joining segment and of the variable amplitude that depends on the distance between the curves. But the determination of such a sine-curve would be rather awkward for calculations. Instead of it, the following function has been applied

$$y = \frac{2abx}{b^2 + x^2}, \tag{2}$$

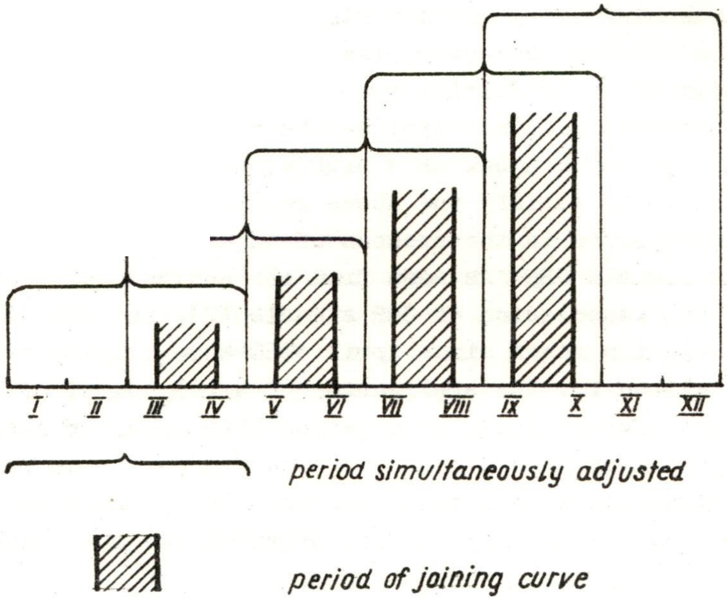

Fig. 2

which is approximated to the sine-curve and at the same time easy to be calculated. In our case the coordinate y signifies the value of the correction *u* and x - the corresponding to it moment T, *a* signifies a half of the difference between two corrections calculated for the same moment from two adjustments and *b* - a half of the length of the semgent comprising the joining curve

$$2a = u_{II} - u_I$$

$$2b = T_k - T_p,$$

where T_p, T_k are the moments at which the joining curve begins and ends.

The afore presented method naturally has its disadvantages. The error of the GBR signal registration passes on the calculation of moments of reception of other singals. It is assumed that the rate of the Q_{11} working clock is linear in between two succesive GBR signals, but this assumption is not always fulfilled - especially when the interval is greater then 24 hours. None the less sum of all these errors (depending on the instrumentation first of all) does not exced ± $0^{s}_{,}002$ in our case.

2. A NUMERAL EXAMPLE

The initial data for the calculation are:

a) the corrections for the Q_{11} clock - u_{Q11},

b) the moments of radio-signals reception registrated in the Q_{11} system.

Table 3 contains a list of observations made in July-November 1963. A five-months period has been taken for, the calculations exceptionally, for lack of observations in October.

Table 4 contains the readings of radio-signals recorded in September 1963 on a chronograph in the system of the Q_{11} clock. The underline signifies the shift of the zero-point of the clock. Table 5 contains the conversion of the observed corrections u_{Q11} into the GBR clock corrections, corrected for the effect of the motion of the pole, of the irregularity of rotation of the Earth and for the constant of the instrumentation delay. Thus: the column 1 comprises the observed clock correction u_{Q11}, the column 2 comprises the Q_{11} clock indications at the moment of GBR signal reception converted into a mean moment of observation, the columns 3 and 4 contain the extrapolated corrections for the motion of the Earth's poles and for the irregularity of the rotation of the Earth. The column 5 comprises the sum of the antecedent columns minus the constant correction for the instrumentation: $0^{s}_{,}0020$, that giving altogether the correction observed for the GBR clock in the system TU 2: u_{GBR}.

The table 6 consists of the system of observational equations of the form (1); columns 1,2 and 3 comprise coefficients: $1, \frac{\Delta T}{10}, \frac{\Delta^2 T}{100}$; column 4 contains a free term l, which (in this case) is the effect of subtraction of the $0^{s}_{,}800$ from u_{GBR}; the

Table 3

No	Date and moment of observation	Observer
1	2	3
1	1963 VII 24,^{d}848	P
2	24,935	P
3	31,864	P
4	31,935	P
5	VIII 1,867	Z
6	1,936	Z
7	2,891	T
8	2,943	T
9	5,847	P
10	5,931	P
11	6,795	T
12	6,843	T
13	12,862	P
14	12,862	Z
15	14,897	P
16	16,779	T
17	16,826	T
18	23,820	T
19	23,867	T
20	24,766	T
21	24,812	T
22	27,796	T
23	27,841	T
24	IX 14,796	P
25	14,862	P
26	16,801	T
27	16,845	T
28	20,750	T
29	20,804	T
30	21,802	Z
31	21,802	P
32	21,867	Z
33	21,867	P
34	23,762	Z
35	23,823	Z
36	XI 9,780	Z
37	28,909	Z
38	28,975	Z
39	29,717	L

Table 4

Date	FYP 8^h	DIZ 8^h	ROR 8^h	GBR 9^h	FYP 9^h	FYP 9^{30}	DIZ 9^{30}	DIZ 12^h	ROR 12^h	DIZ 13^h	FYP 13^h
	1	2	3	4	5	6	7	8	9	10	11
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	000	935	945	990	970	946
3	000	930	975	934	000	000	929	929	974	945	-
4	982	928	956	915	982	-	-	-	-	-	980
5	965	910	-	986	964	-	-	-	-	885	960
6	943	868	918	876	945	947	-	872	917	-	940
7	927	854	902	858	926	926	850	848	898	849	923
8	-	-	-	-	-	-	-	-	-	-	-
9	-	890	865	823	890	047	813	-	-	812	888
10	-	800	848	805	873	-	-	795	845	795	869
11	-	780	830	-	-	855	782	780	830	-	853
12	835	780	812	780	835	840	775	780	811	785	836
13	823	750	795	753	820	822	749	765	794	743	826
14	805	730	780	738	815	807	730	725	777	727	801
15	-	-	-	-	-	-	-	-	-	-	-
16	785	700	750	-	-	775	-	696	747	693	771
17	739	690	764	694	763	-	-	685	734	683	759
18	-	197	249	207	279	277	198	197	245	195	270
19	267	182	234	-	-	-	-	190	230	180	255
20	-	-	-	806	-	-	-	795	846	795	869
21	852	777	826	785	852	850	784	770	820	771	848
22	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	585	652	650	-	-	623	-	650
24	665	557	608	-	-	-	-	554	603	553	629
25	620	542	-	548	615	-	-	540	-	537	612
26	-	-	763	720	790	790	-	-	760	-	777
27	-	940	987	-	-	-	-	-	-	-	-
28	555	480	527	-	556	-	485	480	525	-	-
29	-	-	-	-	-	-	-	-	-	-	-
30	645	565	617	576	645	645	566	-	615	-	642

Table 5

No		$u_{Q_{11obs}}$	Q_{11GBR}	$\Delta\lambda$	ΔT_s	U_{GBR}
		1	2	3	4	5
1	VII.24/25	294	538	-0.002	+0.004	832
2	24/25	360	549	- 2	+ 4	909
3	31/ 1	109	808	- 1	+ 0	914
4	31/ 1	25	799	- 1	0	821
5	VIII. 1/2	214	704	0	- 1	915
6	1/2	276	699	0	- 1	972
7	2/3	294	625	0	- 3	914
8	2/3	297	622	0	- 3	914
9	5/6	508	412	+ 1	- 5	914
10	5/6	514	406	+ 1	- 5	914
11	6/7	591	305	+ 1	- 6	889
12	6/7	614	299	+ 1	- 6	906
13	12/13	792	59	+ 2	- 10	841
14	12/13	835	59	+ 2	- 10	884
15	14/15	914	999	+ 2	- 11	902
16	16/17	959	944	+ 3	- 13	891
17	16/17	000	943	+ 3	- 13	931
18	23/24	969	939	+ 4	- 17	893
19	23/24	989	939	+ 4	- 17	913
20	24/25	973	926	+ 5	- 18	884
21	24/25	949	955	+ 5	- 18	889
22	27/28	567	403	+ 6	- 20	954
23	27/28	546	402	+ 6	- 20	932
24	IX.14/15	189	732	+ 11	- 27	903
25	14/15	176	731	+ 11	- 27	889
26	16/17	204	703	+ 11	- 28	888
27	16/17	157	702	+ 11	- 28	839
28	20/21	115	798	+ 12	- 28	895
29	20/21	107	797	+ 12	- 28	886
30	21/22	156	776	+ 13	- 28	915
31	21/22	183	776	+ 13	- 28	942
32	21/22	189	775	+ 13	- 28	951
33	21/22	130	775	+ 13	- 28	888
34	23/24	337	578	+ 13	- 28	898
35	23/24	351	576	+ 13	- 28	910
36	XI. 9/10	616	360	+ 20	- 21	873
37	28/29	574	418	+ 20	- 14	896
38	28/29	571	418	+ 20	- 14	893
39	29/30	577	422	+ 19	- 13	903

T a b l e 6

No	Date	a	b	c	l	v	v_{cor}
	1963	1	2	3	4	5	6
1	VII. 24/25	1	-5.265	+27.722	+0.032	$+0.063_6$	
2	24/25		5.256	27.631	109	-13_0	
3	31/1		4.564	20.826	114	-16_6	
4	31/1		4.556	20.762	21	$+76_4$	
5	VIII. 1/2		4.463	19.921	115	-17_4	-16_3
6	1/2		4.456	19.860	172	-74_4	-73_3
7	2/3		4.361	19.017	114	-16_1	-15_6
8	2/3		4.356	18.972	114	-16_1	-15_6
9	5/6		4.065	16.527	114	-15_5	-15_6
10	5/6		4.057	16.458	114	-15_5	-15_6
11	6/7		3.970	15.765	89	$+9_7$	$+9_5$
12	6/7		3.966	15.727	106	-7_3	-7_5
13	12/13		3.364	11.315	41	$+59_0$	$+59_0$
14	12/13		3.364	11.315	84	$+16_0$	$+16_0$
15	14/15		3.160	9.988	102	-1_7	
16	16/17		2.972	8.833	91	$+9_6$	
17	16/17		2.967	8.805	131	-30_4	
18	23/24		2.268	5.144	93	$+8_7$	
19	23/24		2.263	5.122	113	-11_3	
20	24/25		2.173	4.724	84	$+17_8$	
21	24/25		2.169	4.704	89	$+12_8$	
22	27/28		1.870	3.498	154	-51_9	
23	27/28		1.866	3.482	132	-29_1	
24	IX. 14/15		0.070	0.005	103	$+0_3$	
25	14/15		-0.064	0.004	89	$+14_3$	
26	16/17		+0.130	0.017	88	$+15_3$	
27	16/17		0.134	0.018	39	$+64_3$	
28	20/21		0.525	0.276	95	$+8_3$	
29	20/21		0.530	0.281	86	$+17_3$	
30	21/22		0.630	0.397	115	-11_7	
31	21/22		0.630	0.397	142	-38_7	
32	21/22		0.637	0.405	151	-47_7	
33	21/22		0.637	0.405	88	$+15_3$	
34	23/24		0.826	0.683	98	$+5_3$	
35	23/24		0.832	0.693	110	-6_7	
36	XI. 9/10		5.528	30.559	73	$+24_1$	
37	28/29		7.441	55.367	96	-4_6	
38	28/29		7.448	55.465	93	-1_6	
39	29/30		+7.522	+56.576	+0.103	-11_9	

column 5 contains the adopter v computed after having solved the system of normal equations that is shown in the table 7.

On the basis of the calculated values of u_o, ω_o, ω' we compute the curve of corrections adjusted for the whole period excluding tze very ends of the curve as useless. The curve is computed in the table 8.

We may now calculate the joining curve according to the formula (2). The calculation is shown in the table 9, the formula (2) is presented in the form

$$u = \frac{u_1 \cdot k_1 + u_2 \cdot k_2}{k_1 + k_2}, \qquad (3)$$

where u_1, u_2 are two values of a correction for the same date, computed from two adjustments

$$k_1 = (31 - n)^2; \qquad k_2 = n^2$$

and n is the number of days that the joining curve includes.

Having got u_{GBR} computed for the whole period we can proceed with the calculation of TU 2 moments of other signals reception. For this purpose we calculate the indications of the GBR clock at the moments of other signals reception (table 10). The indication for any signal, e.g. FYP, is found to be

$$GBR_{FYP} = Q_{11(FYP)} - Q_{11(GBR)} - \frac{\Delta T \cdot Q_{11(GBR)}}{1^d}, \qquad (4)$$

where Q_{11} is the indication of the clock at the moment of the given signal reception; T is the time interval between the GBR (9^hTU) signal and the given one; $\frac{\Delta Q_{11(GBR)}}{1^d}$ is the variation of the indication during one day, evidently the zero value of a variation is always obtained for the GBR signal.

Having these data and the correction u_{GBR} for any moment it is easy to compute the TU 2 moments of radio-signals reception, what is shown in the table 11.

In the table 6 the adopters v have to be yet corrected for the period in which the smoothed curve has been replaced by the joining curve. It is done in the column 6.

Table 7

Adjustment of result of time observations

+ 39.000	- 48.457	+ 517.667	+ 3.897
	+ 517.666987	+ 122.398970	- 4.938001
		+15860.703867	+49.765622

$x = + 0.103347_2$ $y = + 0.000019_2$ $z = - 0.000002_4$

$m_x = \pm 0.0077$ $m_y = \pm 0.00016_2$ $m_z = \pm 0.000003_2$

$[\,ll\,] = + 0.426067$

$[\,LL\,] = + 0.389840$

$[\,ll\,] - [\,LL\,] = 36227$

$[\,vv\,] = 36196$

$$m_o = \sqrt{\frac{[\,vv\,]}{36}} = \pm 0.031_7$$

$u_o = .8000 + 0.1033 = + .903_3 \pm 0.0077$

$\omega_o = + 0.000019 \pm 0.000162$

$\gamma = - 0.0000024 \pm 0.000003$

Table 8

$u_o = .9033$ $\omega_o = +0.000019$ $\gamma = -0.0000024$ $u_{GBR} = u_o + \Delta T \cdot \omega_o + \Delta^2 T$.

Epoch 12^h	$\omega_o \cdot \Delta T$	$\gamma \cdot \Delta^2 T$	u_{GBR}
1	2	3	4
1963.VII.15	-0.0012	-0,0092	^{s}.8929
16	12	89	8932
17	11	86	8936
18	11	84	8938
19	11	81	8941
20	11	78	8944
21	11	75	8947
22	10	73	8950
23	10	70	8953
24	10	67	8956
25	10	65	8958
26	10	62	8961
27	10	60	8963
28	9	58	8966
29	9	55	8969
30	9	53	8971
31	9	51	8973
VIII. 1	9	49	8975
2	8	46	8979
3	8	44	8981
4	8	42	8983
5	8	40	8985
6	8	38	8987
7	7	37	8989
8	7	35	8991
9	7	33	8993
10	7	31	8995
11	7	29	8997
12	6	28	8999
13	6	26	9001
14	6	25	9002
15	6	23	9004
16	6	22	9006
17	6	20	9008
18	5	19	9009
19	5	17	9011
20	5	16	9012
21	5	15	9013
22	5	14	9014
23	4	13	9016
24	4	11	9017
25	4	11	9018
26	4	10	9019
27	4	9	9020

1	2	3	4
28	3	8	9022
29	3	7	9023
30	3	6	9024
31	3	5	9025
IX. 1	3	5	9025
2	2	4	9027
3	2	3	9028
4	2	3	9028
5	2	2	9029
6	2	2	9029
7	2	2	9029
8	1	1	9031
9	1	1	9031
10	1	-0.0001	9031
11	1	0	9032
12	-0.0001	0	9032
13	0	0	9033
14	0	0	9033
15	0	0	9033
16	0	0	9033
17	0	0	9033
18	+0.0001	0	9034
19	1	0	9034
20	1	-0.0001	9033
21	1	1	9033
22	1	1	9033
23	2	2	9033
24	2	2	9033
25	2	2	9033
26	2	3	9032
27	2	3	9032
28	2	4	9031
29	3	5	9031
30	3	5	9031
X. 1	3	6	9030
2	3	7	9029
3	3	8	9028
4	4	9	9028
5	4	10	9027
6	4	11	9026
7	4	12	9025
8	4	13	9024
9	5	14	9024

1	2	3	4
10	5	15	9023
11	5	16	9022
12	5	17	9021
13	5	19	9019
14	6	20	9019
15	6	22	9017
16	6	23	9016
17	6	25	9014
18	6	26	9013
19	6	28	9011
20	7	29	9011
21	7	31	9009
22	7	33	9007
23	7	35	9005
24	7	37	9003
25	8	38	9003
26	8	40	9001
27	8	42	8999
28	8	44	8997
29	8	46	8995
30	9	49	8993
31	9	51	8991
XI. 1	9	53	9989
2	9	55	9987
3	9	58	9984
4	10	60	9983
5	10	62	9981
6	10	65	9978
7	10	67	9976
8	10	70	9973
9	10	73	9970
10	11	75	9969
11	11	78	9966
12	11	81	9963
13	11	84	9960
14	11	86	9958
15	12	89	9956
16	12	92	9953
17	12	95	9950
18	12	98	9947
19	12	101	9944
20	13	105	9941
21	13	108	9938
22	13	111	9935
23	13	114	9932
24	13	118	9928
25	13	121	9925
26	14	124	9923
27	14	128	9919
28	14	131	9916
29	14	135	9912
30	+0.0014	-0.0139	9908

Table 9

1963	n	u_1	k_1	u_2	k_2	u
VII.15	1	.9177	900	.8929	1	.9177
16	2	9167	841	8932	4	9166
17	3	9158	784	8936	9	9155
18	4	9150	729	8938	16	9145
19	5	9141	676	8941	25	9134
20	6	9131	625	8944	36	9121
21	7	9121	576	8947	49	9107
22	8	9112	529	8950	64	9095
23	9	9102	484	8953	81	9081
24	10	9092	441	8956	100	9067
25	11	9082	400	8958	121	9053
26	12	9072	361	8961	144	9040
27	13	9063	324	8963	169	9029
28	14	9052	289	8966	196	9017
29	15	9042	256	8969	225	9008
30	16	9031	225	8971	256	8999
31	17	9022	196	8973	289	8993
VIII.1	18	9012	169	8975	324	8988
2	19	9002	144	8979	361	8986
3	20	8992	121	8981	400	8983
4	21	8982	100	8983	441	8983
5	22	8972	81	8985	484	8983
6	23	8962	64	8987	529	8984
7	24	8951	49	8989	576	8986
8	25	8941	36	8991	625	8988
9	26	8932	25	8993	676	8991
10	27	8922	16	8995	729	8994
11	28	8911	9	8997	784	8996
12	29	8902	4	8999	841	8999
13	30	8893	1	9001	900	9001

Table 10

September 1963

Date	FYP 8	DIZ 8	ROR 8	GBR 9	FYP 9	FYP 9^{30}	DIZ 9^{30}	DIZ 12^h	ROR 12^h	DIZ 13	FYP 13
	1	2	3	4	5	6	7	8	9	10	11
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	047	982	994	039	-	-
3	065	995	040	0	066	066	995	997	042	014	-
4	066	012	040	0	067	-	-	-	-	-	068
5	068	013	-	0	068	-	-	-	-	992	067
6	066	991	041	0	069	071	-	998	043	-	067
7	068	995	043	0	068	068	992	992	042	994	068
8	-	-	-	-	-	-	-	-	-	-	-
9	066	-	041	0	067	-	990	-	-	992	068
10	-	994	042	0	068	-	-	992	042	993	067
11	-	992	042	-	-	068	995	995	045	-	069
12	064	009	041	-	065	070	005	012	043	-	069
13	069	996	041	0	067	069	996	014	043	992	075
14	066	991	041	0	075	069	992	989	041	991	065
15	-	-	-	-	-	-	-	-	-	-	-
16	075	990	040	-	-	066	-	989	040	988	064
17	-	995	-	0	069	-	-	992	042	991	067
18	-	989	041	0	072	070	991	992	040	990	065
19	074	989	041	-	-	-	-	000	040	990	065
20	0	0	0	0	-	-	-	991	042	992	065
21	066	991	040	0	067	065	999	987	037	989	066
22	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	0	067	065	-	-	040	-	067
24	067	990	041	-	-	-	-	990	039	990	066
25	071	993	-	0	067	-	-	994	-	992	067
26	-	-	042	0	070	070	-	-	042	-	060
27	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-
30	068	988	040	0	069	069	990	-	041	-	069

Table 11

September 1963

Date	FYP 8^h	DIZ 8^h	ROR 8^h	GBR 9^h	FYP 9^h	FYP 9^{30}	DIZ 9^{30}	DIZ 12^h	ROR 12^h	DIZ 13^h	FYP 13^h
1	2	3	4	5	6	7	8	9	10	11	
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	950	885	897	942	-	-
3	968	898	943	903	969	969	898	900	945	917	-
4	969	915	943	903	970	-	-	-	-	-	971
5	971	916	-	903	971	-	-	-	-	895	970
6	969	894	944	903	972	974	-	901	946	-	970
7	971	898	946	903	971	971	895	895	945	897	971
8	-	-	-	-	-	-	-	-	-	-	-
9	969	-	944	903	970	-	893	-	-	895	971
10	-	897	945	903	971	-	-	895	945	896	970
11	-	895	945	-	-	971	898	898	948	-	972
12	967	912	944	-	968	973	908	915	946	-	972
13	972	899	944	903	970	972	899	917	946	895	978
14	969	894	944	903	978	972	895	892	944	894	968
15	-	-	-	-	-	-	-	-	-	-	-
16	978	893	943	-	-	969	-	892	943	891	967
17	-	898	-	903	972	-	-	895	945	894	970
18	-	892	944	903	975	973	894	895	943	893	968
19	977	892	944	-	-	-	-	903	943	893	968
20	-	-	-	-	-	-	-	894	945	895	968
21	969	894	943	903	970	968	902	890	940	892	969
22	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	903	970	968	-	-	943	-	967
24	970	893	944	-	-	-	-	893	942	893	969
25	974	896	-	903	970	-	-	897	-	895	970
26	-	-	945	903	973	973	-	-	945	-	963
27	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-
30	971	891	943	903	972	972	893	-	944	-	972

3. FINAL REAMRKS

A deficiency of the considered method, which is of technical nature rather, is the unavoidable delay of more then two months. This being the time we have to wait for the determination of the segment of a joining curve, closing the antecedent normal sagment. The essential advantage of the method lies in the utilization of the excellent quality GBR clock instead of an observator's own clóck.

Until now different observatories apply diverse methods for data processing. For that reason the published results are to some extent incomparable because, as it was mentioned above, the method of adjustment has a very strong bearing on numeral effects. This is to be seen very clearly from diagrams annually published in Circulaire BIH where different short-period oscillations of several curves result from the smoothing method applied.

It seems purposeful to admit an uniform method of smoothing for all the observatories participating in the International Time Service. It would then be convenient to offer to the observatories the possibility of adjusting the same clock, for instance GBR or WWV or others. It is also possible to admit two or three clocks if one radiostation can not be well heard all over the world. This would enable the unification of results, and also an easier comparison of their accuracy by applying the standard formulae for the mean errors of the unknowns determined.

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УРАВНИВАНИЕ РЕЗУЛЬТАТОВ НАБЛЮДЕНИЙ ВРЕМЕНИ В АСТРОНОМО-ГЕОДЕЗИЧЕСКОЙ ОБСЕРВАТОРИИ ВАРШАВСКОГО ПОЛИТЕХНИЧЕСКОГО ИНСТИТУТА В ЮЗЕФОСЛАВЕ

Краткое содержание

В статье описан метод применяемый в Астрономо-Геодезической Обсерватории Варшавского Политехнического Института. В основе метода лежит использование в качестве главных часов радиосигналов ГВР наблюденные поправки которых подвергаются уравновешанию. Это разрешает увеличить период в котором наблюдения должны быть совместно уравнены. В заключении автор предлагает введение одинакого метода уравнивания во всех Обсерваториях Международной Службы Времени, что облегчилобы сравнение результатов и оценку их точности.