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Determination of the Longitude of the Tartu Observatory by the Wireless

First paper:

Observations with the Old Dollond Transit Instrument in 1927

By

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1. Introduction.

The longitude of the meridian-circle of the Tartu (Dorpat) Observatory is according to „Albrecht's Compensation“ (Astronomische Nachrichten № 3993—94) $1^h\ 46^m\ 53^s.22$ east from Greenwich. This result is derived from the measurements of the years 1879 (Tartu—Pulkovo) and 1885 (Riga—Tartu) and it has been used traditionally till now. To this time these results have not been controlled [1]).

By the aid of the wireless it is nowadays rather easy to determine the geographical longitude of a point. This paper contains a preliminary series of such determinations for the Tartu Observatory. As the instrument used was very old naturally the results have been influenced. On the other hand it was interesting to see what a precision an instrument is able to give, which has been used for more than hundred years. We hope in the next future to repeat the determinations with a modern instrument.

The observations were made in three groups in the year 1927: 5 nights in April and May with a chronograph, 6 nights in August and September using the eye-ear method and 7 nights in October and November with a chronograph.

I should like to express my sincerest thanks to Messrs. O. Silde, P. Simberg and Dr. E. Öpik for their aid and kind advice in the present work.

2. The Instruments and Methods Used.

1. The transit-instrument.

The transit-instrument was obtained from Dollond in the year 1807. (J. W. Pfaff. De tubo culminatorio Dorpatensi brevis narratio. 1808.). In the present observatory it was mounted by

1) According to K. Pokrovsky (Tartu Publications vol. XXIV part. 1. 1914.) the longitude between Pulkovo and Tartu has been once more determined by Pomerantzev and Rylke.

F. G. W. Struve in 1813. The instrument is placed in the east-hall of the observatory[1]) on two brick piers going down 14 feet under the surface of the earth. The meridian-opening is only 0.36 meter wide[2]). Next to the observation-room there is a heated room. Although before the observations the room was ventilated, the images were often disturbed and it is possible, that a sensible lateral refraction has taken place.

The length of the tube is 1.60 meters, length of the axis 1.20 meters and the diameter of the objective 108 mm. About 50 years ago the instrument was partly reconstructed and a new objective was placed in. On one side of the axis there is a hollow for the illumination of the wires. In the focal plane are fixed 14 wires. Their distances from the middle wire were determined in spring before the observations and in autumn after the observations and compared with the micrometer-screw measurements of the collimator. There was a systematical difference of $0^s.002$ between the two determinations, which was neglected and the mean of both was taken. On the equator these distances were (position „clamp east"):

I	$30^s.31$	VIII	$0^s.00$
II	19.97	IX	1.04
III	10.14	X	2.40
IV	7.10	XI	2.95
V	3.04	XII	7.20
VI	2.50	XIII	10.18
VII	1.31	XIV	20.15

The pivots are of the same material as the right-angle V's and during the numerous observations for more than hundred years sensibly worn. On the V's were rather large cylindrical traces. (After the observations the V's were repolished by the mechanician Mr. Siilbaum in 1928). The mean inequality of pivots was determined with the aid of a level by reversing the instrument as follows:

In 1924.	$0^s.008$
	$0^s.031$
In 1927.	$0^s.030$
	$0^s.041$

1) 13. 1 meters eastwards from the meridian circle.

2) Not 0.61 meter, as given in Tartu Publications Tome XXII p. 182.

In 1927. $0^s.021$
$0^s.044$
$0^s.034$

As the final value was adopted: the radius of the pivot on the side of the clamp being thinner by $0^s.030$. It may be remarked that this value has no influence on the observations, since these were made in two reversed positions of the instrument, and as this value has been taken into account, determining the lateral flexure after the observations. On the repolished V's the inequality of pivots was found exactly the same [1]).

The examination of the irregularities of pivots was made with a small level-apparatus. A little good level was placed on the upper surface of a pivot perpendicularly to the direction of the axis and the corresponding readings made in different zenith-distances. Since the pivots were sensibly worn the measures showed in some cases great irregularities of about 1″ from the middle position. But both pivots are worn almost in the same manner and so the difference of irregularities which influences the inclination of the axis is much smaller. The following table contains these differences. A „+" denotes east being higher. Zenith-distances are positive south from zenith.

Position „Clamp east"			Position „Clamp west"		
Z	Old V's	New V's	Z	Old V's	New V's
+ 0°	−0″.0	−0″.4	− 0°	−0″.4	−0″.0
10°	−0″.0	−0″.4	10°	−0′.3	−0″.0
20°	−0″.0	−0″.3	20°	−0″.3	−0″.0
30°	−0″.1	−0″.4	30°	−0″.4	−0″.1
40°	−0″.3	−0″.2	40°	+0″.0	+0″.3
50°	−0″.2	−0″.3	50°	+0″.2	+0″.3
60°	+0″.2	−0″.3	60°	+0″.5	+0″.8
70°	−0″.1	−0″.1	70°	+0″.1	−0″.0
80°	−0″.3	−0″.0	80°	+0′.1	+0″.0
90°	−0″.3	−0″.1	90°	+0″.0	−0″.1
100°	−0″.3	−0″.0	100°	+0″.1	+0″.0
110°	−0″.2	+0″.2	110°	+0″.2	+0″.1
120°	+0″.5	+0″.3	120°	+0″.1	+0″.3
130°	−0″.0	+0″.1	130°	+0″.0	−0″.0

1) In the Publ. of the Tartu (Dorpat) Observatory vol. XXII. L. Struve finds after some measurements of F. W. G. Struve the inequality of pivots being about zero.

Position „Clamp east"			Position „Clamp west"		
Z	Old V's	New V's	Z	Old V's	New V s
+140°	—0″.0	+0″.4	—140°	+0″.0	—0″.2
150°	—0″.0	+0″.2	150°	—0″.1	—0″.2
160°	+0″.1	+0″.3	160°	—0″.1	—0″.2
170°	—0″.0	+0″.1	170°	+0″.0	—0″.1
180°	+0″.2	+0″.0	180°	+0″.2	—0″.0
190°	+0″.2	+0″.2	190°	+0″.0	+0″.1
200°	+0″.2	+0″.3	200°	+0″.1	+0″.2
210°	+0″.2	+0″.1	210°	—0″.1	—0″.2
220°	+0″.2	+0″.2	220°	+0″.0	—0″.2
230°	+0″.2	+0″.1	230°	+0″.1	—0″.5
240°	+0″.7	+0″.2	240°	+0″.3	+0″.3
250°	+0″.2	+0″.3	250°	+0″.4	+0″.3
260°	+0″.1	+0″.2	260°	+0″.3	+0″.1
270°	—0″.3	—0″.1	270°	+0″.1	+0″.0
280°	—0″.3	+0″.3	280°	+0″.4	+0″.3
290°	—0″.3	+0″.0	290°	+0″.1	+0″.2
300°	+0″.2	+0″.1	300°	+0″.0	+0″.2
310°	—0″.2	+0″.1	310°	+0″.0	—0″.1
320°	—0″.2	—0″.0	320°	—0″.2	—0″.2
330°	—0″.2	+0″.1	330°	—0″.4	—0″.4
340°	—0″.2	—0″.2	340°	—0″.4	—0″.3
350°	—0″.1	—0″.2	350°	—0″.4	—0″.3
360°	—0″.1	—0″.2	360°	—0″.5	—0″.2

We can see that the differences depend on the position of the instrument and that they may influence the transit observations only on a few hundreths of a second. As the above observations on the whole were not very precise the corrections for the irregularities of pivots were not calculated and the effect of these irregularities was n o t taken into account.

The tube of the transit instrument shows a great l a t e r a l f l e x u r e. That means that the collimation is not a constant but a function of zenith-distance, for instance

$$c = c_0 + \alpha . \cos z + \beta . \sin z,$$

where c_0, α and β are constants.

The constants α and β were calculated from the star observations in the positions „clamp east" and „clamp west" which differ more or less if a lateral flexure exists. Knowing horizontal collimation and inclination of the instrument, and supposing that the azimuth of the instrument has not changed during the observations we have:

„clamp east“:

$$AR_1 = T_1 + u + \text{corrections for horiz. collim. and incl.} + \\ + a . \sin z_1 . \sec \delta_1 + \alpha . \cos z_1 . \sec \delta_1 + \beta . \sin z_1 \sec \delta_1 - \beta . \sec \delta_1 .$$

„clamp west“:

$$AR_2 = T_2 + u + \text{corrections for horiz. collim. and incl.} + \\ + a . \sin z_2 . \sec \delta_2 - \alpha . \cos z_2 . \sec \delta_2 - \beta . \sin z_2 . \sec \delta_2 + \beta . \sec \delta_2 .$$

where AR means the right ascension of a star, δ the declination, T observed transit time, u the clock correction, a the azimuth constant and α, β the constants of lateral flexure. The term $\beta . \sec \delta$ denotes the reduction of horizontal collimation to the value c_0. Substracting the second equation from the first we have

$$AR_1 - AR_2 = T_1 - T_2 + \triangle + a (\sin z_1 . \sec \delta_1 - \sin z_2 . \sec \delta_2) + \\ + \alpha (\cos z_1 . \sec \delta_1 + \cos z_2 . \sec \delta_2) + \beta (\sin z_1 . \sec \delta_1 + \sin z_2 . \sec \delta_2) - \\ - \beta (\sec \delta_1 + \sec \delta_2),$$

where $\triangle$ denotes the difference of corrections for horizontal collimation and inclination between these stars. When the declinations of these two stars are nearly equal we have a linear equation with two unknowns α and β. The solution of a system of such equations gives us α and β. Since the instrument is mounted in a stable manner, the azimuth varies slowly and we can also calculate α and β from observations which differ in time by 1 or 2 days, the change of clock corrections being given by the wireless. The calculations were made by successive approximations taking into account the variations of azimuth in observations which are not made on the same day.

The equations showed that β must be small, and so the simplest law was adopted

$$c = c_0 + \alpha . \cos z$$

As the final value of α was adopted:

$\alpha = - 0^s.15_5$ for chronograph observations,
$\alpha = - 0^s.19_5$ for eye-ear observations.

There is a systematical difference between these two methods of observation. This may be partly real, partly depending on the errors of determinations, but it is also quite possible that the personal equation changes a little by reversing the instrument and that this change is not the same for the two methods of observation. Such a small change of the relative personal equation seemed to be indicated on the simultaneous observations of Mr.

O. Silde and the writer. On the transit observations in 1926 at Helwân P. A. Curry finds similar differences in the direct and reversed position of the instrument [1]).

The above-mentioned values of a were used correspondingly in the reductions of the observations. It may be remarked that these values include also the change of the personal equation of the observer. A small error in the adopted values of a will have no influence on the time and longitude determinations when these have been taken in two reversed positions of the instrument.

F. G. W. Struve finds in 1821

$$a = -0^s.271.\ \beta = 0^s.000.^{2)}$$

In the mean while the instrument was partly reconstructed and it is clear that nowadays the lateral flexure may be quite different.

2. Determination of the collimation.

In April and May the collimation was determined with a horizontal collimator by reversing the instrument. Later on, when the observations were continued in two positions of the instrument, there were found great systematical differences between the time determinations in the two positions (depending on the lateral flexure). Thus it seemed necessary to control the collimation determinations. For this purpose a second temporary collimator was mounted and so it was possible to determine the collimation in two ways without and by reversing the instrument. Both collimators were placed on brick-piers, which were once specially constructed for this purpose. The line of sight of the two collimators was pointed by lifting the transit instrument. It was found that there was no sensible difference between the two ways of determination and so the mean of both was taken. The values of the determined horizontal collimation corrections were as follows („clamp east").

April	12-th	1927.	$-0^s.290$	one	collimator
April	16-th		$-0^s.295$	„	„
April	23-rd		$-0^s.298$	„	„
Mai	4-th		$-0^s.306$	„	„
August	9-th		$-0^s.323$	„	„

1) Monthly Notices vol. 87 page 497.

2) Tartu (Dorpat) Publications. vol. XXII page 189.

August	17-th	— $0^s.325$	one collimator
September	3-rd	— $0^s.270$	two collimators. The new collimator not stable enough? Adopted value — $0^s.290$.
October	11-th	— $0^s.329$	two collimators + one collimator. Adopted value — $0^s.320$.
October	21-st	— $0^s.304$	two collimators + one collimator.
November	17-th	— $0^s.302$	two collimators + one collimator.

We see that the results show a rather small and smooth variation of the collimation and so the values for the single days of observation were taken by simple interpolation.

The star observations showed that an imaginable deviation of „the true collimation constant" from the measured collimation cannot explain the star observations and that a cosinus-law or a lateral flexure must exist.

3. The level.

The inclination of the axis of the transit instrument was determined by a striding level resting on the pivots. The value of divisions of the level was determined twice during the observation period and for a half-division was found

$$\frac{\tau}{2} = 0.^s029_0 \text{ for the equator.}$$

The level readings were made usually three times during an observation night: before, in the middle and after the observations. In the nights when the transit instrument was reversed there were made four determinations of inclination, two in each position of the instrument. From the table of observations it may be seen that the inclination of the instrument remains more or less constant during a long time when it is not changed purposely.

4. The clocks and the chronograph.

The observations in April, May, October and November were registered with a hand key. The clock used was a *Hohwü* sidereal time clock with mercury compensated pendulum. The clock is placed in a heated room, the so called „clock-room", in the middle of the observatory building. An air-pressure compensation does not exist. The temperature deviations from the mean during a month attaining only about 1°, it was adopted that the clock rate is linear during some hours between the time determinations and the reception of the wireless. The *Hohwü* clock was compared before and after each observation with a *Löbner* mean time clock possessing a *Riefler* pendulum. Beside that the clock comparisons were made often in day time after the reception of the Nauen noon time signals. The *Hohwü* clock possesses an electrical second contact which consists of two opposite small pipes filled with mercury. A very thin isolating mica plate fixed on the pendulum each second connects and interrupts a weak electric current led through the pipes. The contact is connected by a relay with a *Fuess* pricking chronograph. In April and May the relay and the mica plate were so placed that the choronograph worked at these moments when the contact conducted an electrical current. Then the contact worked well. In summer when the writer was absent and no observations were made the mica plate was broken and in autumn a new mica plate was put in. Since the new constructed contact did not work satisfactorily the mica plate was changed and the relay was reconstructed according to a proposal of Dr. Öpik so, that the chronograph worked at these moments when the electrical current was interrupted. Then the contact worked satisfactorily and the second-points on the chronograph strip were in this way determinated very precisely. In August and September when the contact was broken the time determinations were made by the eye-ear method with the aid of the chronometer *Ericsson* № 74. The chronometer was compared with the *Löbner* clock before and after each observation.

The *Fuess* pricking chronograph has two equal levers with corresponding electromagnets, one for the clock and the other for the transit observations. The parallax of the lever-ends was determined twice and found as $0^s.024$. The paper-strip was driven by a spring-mechanism. The intervals between the second-points were about 1 cm. The electric current was taken from a 4-Volt Varta accumulator. With the aid of a small reostate the same accumulator gives a weak current for the clock contact.

5. The reception of the wireless.

In April and May we received the Nauen noon time signals by a telephon from the Tartu (Dorpat) radio-station situated about

$1^1/_2$ klm. *NE* from the observatory. The wave-length used was $\lambda = 18.000$ m. The noon rhythmic time signals were compared by ear with the beats of the *Löbner* clock. In May the observatory received its own radio-apparatus system Telefunken with 5 lamps made by the Tartu Telephon-Manufactury. With this apparatus we can receive signals from $\lambda = 250$ m. to $\lambda = 3.500$ m. So in autumn we received the Nauen time signals ($\lambda = 3.100$ m.) on each observation night and as frequently as possible the Nauen noon time signals. In October and November the noon and midnight signals from Eiffel-Tower (*FL*; $\lambda = 2650$ m.) were also received. All signals were compared by ear with the *Löbner* clock. The reception of the noon signals in October and November was often disturbed by Röntgen apparatuses of hospitals located near the observatory.

At first it seems that on the reception by the method just described there may be expected a little personal equation depending on the observer. The corrections of the time signals are published for the beginning of each signal. Since the signals have a short duration the observer may notice the coincidence not of the beginning of the signal with the clock, but a little later. Later on, after ending the observations with the transit instrument it was possible to receive the signals according to the emersion method of Hänni [1]) and to compare them with the method used in the present longitude determinations. It was found that if such a personal equation exists it must be very small (smaller than $0^s.01$), at least for the shorter Nauen signals. (For the longer Eiffel signals there seemed to exist, prabably due to errors of observation and to the inequality of clock-seconds, curiously enough a small personal equation in the opposite direction.) Therefore no corrections for the personal equation on the reception of time signals were taken into account.

In the second half of October there was a great systematical difference between the Nauen and the Eiffel-Tower signals, the latter being relatively to Nauen too late on the average by $0^s.14 \pm 0^s.006$ (probable error). In November this difference is smaller. Only a little part of this systematical difference may be attributed to some reception or personal equation causes. The

1) F. Baeschlin. Uhrvergleichungen auf drahtlosem Wege etc. Astron. Nachrichten № 5249.

major part seemed to exist really, depending upon the adopted longitudes, the time determinations, perhaps also upon other causes affecting the radio waves between Hamburg and Paris. The same difference is well illustrated in Greenwich Observations 1922—1925 and in Bulletin Horaire du B. I. H., where it may also be seen that this difference is slowly varying.

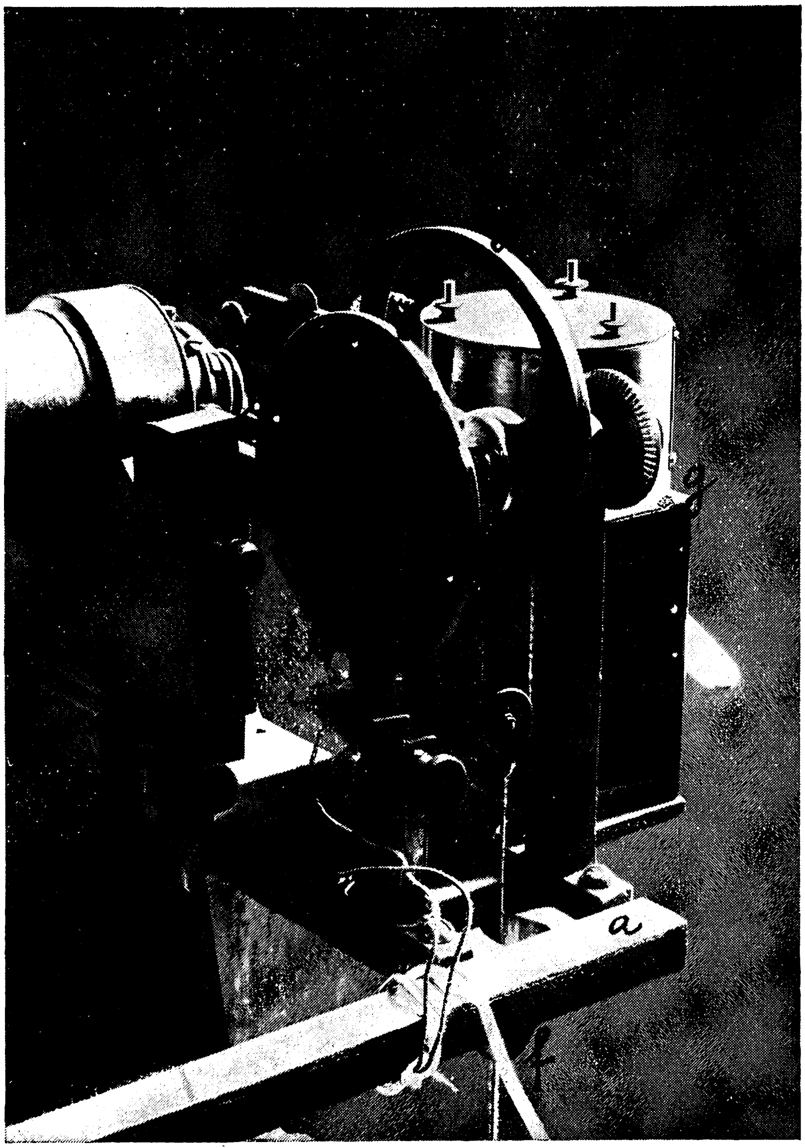
For the reduction of time signal observations were used tables of the Russian Astronomical Institute. The corrections of the signals were taken for Nauen from „Beobachtungs-Zirkulare der Astron. Nachrichten" and for Eiffel from „Bulletin Horaire du B. I. H."

6. Description of the personal equation apparatus.

It is a wellknown fact, that there may be great personal equations in the transit observations with eye-ear method and in the registration with a hand-key, which sometimes reach many tenths of a second. In modern observations with a self-registering micrometer the personal equation is much smaller, but it is possible that it can reach a few hundreths of a second. Since the present observations were made without a self-registering micrometer it was necessary to determine the personal equation of the transit observations.

With regard to our finances it was possible for us only to construct a simple personal equation apparatus. The apparatus was constructed by the mechanician Mr. P. Siilbaum.

The apparatus consists of a stable basis (a) with two well polished rails (b). On the rails moves a small right-angle platform (c) with an artificial star; the last consists of a thin tin plate with a very small hole, behind which there is placed a little electric lamp. Since the movement of the arficial star must be practically without any back-lash the kind of movement was examined from several points of view. The proposition of Mr. O. Silde was adopted in which the movement of the platform is caused by the rotation of an excentrically placed bronze wheel of the form of two opposite evolvents of a ring (d). The polished edge of the evolvent-shaped wheel drives the platform on rails with a constant speed. The platform is always pressed on the evolvent-shaped wheel simply by a small counter-balance (f).



2. The personal equation apparatus mounted at the ocular end of the collimator.

K. Mattiesen, Tartus.

The rotation goes only in one direction, the platform making in one revolution the way there and back. For the personal error observations were used only those movements of the artificial star in which the platform (c) was pushed forwards by the wheel. The rotation of the wheel with a constant angular speed is caused by a spring-driven clock-work (g) with a regulator.

On the same axis of the evolvent-shaped wheel there is fixed a simple metallic round wheel (e), in a manner that both wheels rotate together. On the round wheel are fixed three metallic contacts (h) which give in each revolution a short electric contact with a small spring (i). The tangent point is sharply defined by a thin wire fixed on the surface of the spring (i). The contacts (h) and the spring (i) may be regulated with the aid of little screws. In this way an electric contact is always produced automatically when the artificial star enters in a certain exactly defined position. It seems that for such a simple apparatus the errors are eliminated as much as possible.

The radius of the evolvent-shaped wheel (d) amounts from 3 cm. to 7 cm. in the opposite direction. So the platform (c) has a movement of the amplitude of 4 cm. The radius of the round contact wheel (e) is 5 cm. The period of revolution of the wheels may be regulated from $4^3/_4$ to 7 minutes.

The apparatus was mounted on the collimator pier behind the ocular end of the collimator. This enabled to observe the movement of the artificial star in the same Dollond transit instrument through the collimator. The artificial star was quite similar to a natural star image and the movement seemed smooth and constant with about the same speed as that of a natural star image.

The plan and several technical details of the apparatus were made by Mr. P. Simberg.

For the determination of the personal equation the image of the artificial star was put exactly on a wire in the transit instrument by the movement of the micrometer screw of the collimator ocular and then the contacts (h) were regulated so that they just gave the electric contact. We may also reverse the process by moving the contact wheel (e) very slowly with the regulator of the clock-work (g) exactly till the contact occured and than put the star image on a wire in the transit instrument with the micrometer screw of the collimator. It is not necessary that all contacts should occur when the star image is exactly on any wire of the transit instrument. When the differences are very small they may be measured with the micrometer screw and taken into account.

The apparatus had to become ready in April 1927., but for several delays we received it only at the end of October. After the first installation and examination of the apparatus, the personal equation determinations were made in November; they gave for the writer (a „+" denotes observer being too early):

Begin of November: $+0^s.035$
(unknown date)
November 9-th: $-0^s.010$
November 22-nd: $+0^s.016$
November 28-th: $-0^s.007$

The first observations were taken with a relative weight of 0.2 in accordance with the observed number of contacts. The mean value of the writer's absolute personal equation was therefore equal to zero.

The relative personal equation between Mr. Silde and the writer determined by the same apparatus was found in November as follows: L.—S. $= +0^s.07 \pm 0^s.01$. On simultaneous star observations on November 21-st 1927 with the Dollond transit instrument the relative personal equation revealed a systematical difference in the opposite positions of the instrument, but the mean of both was again L.—S. $= +0^s.04_5 \pm 0^s.04$. The measures with the apparatus show no appreciable difference in opposite positions of the transit instrument. On March 9-th 1928 the absolute personal equation of the writer was determined as $-0^s.06$, and the relative personal equation determined with the apparatus: L.—S. $= -0^s.01 \pm 0^s.02$. The star observations in march 12-th 1928 showed again a small dependence upon the position of the transit instrument, but the mean result was: L.—S. $= -0^s.00_5 \pm 0^s.01_5$.

3. The Transit Observations.

The present table gives the time determinations with the transit instrument. The determined clock corrections are calculated for the chronograph of the *Hohwü* clock and in August, September for the chronometer *Ericsson* № 74. All star positions were taken from the American Ephemeris 1927 with the corrections there given. The diurnal aberration was added to the given right-ascensions. In the reductions Mayer's formula was used as follows

$$AR = T + u \pm c.\sec\delta + (i \pm \alpha \pm p).\cos z.\sec\delta + a.\sin z.\sec\delta$$

(upper culmination, south of zenith; + for „clamp east", and — for „clamp west"), where AR denotes the right ascension and δ the declination of a star, T — the observed time of transit reduced to the middle wire, u — the clock correction, i—the measured inclination of the axis of the transit instrument, α — the constant of lateral flexure, p — the inequality of the pivots, a — the azimuth correction and z — the zenith distance of the star. It may be seen that the inequality of the pivots and the lateral flexure have just the same influence as an „unmeasured" inclination (see page 7).

Each star observation gives us a linear equation with two unknowns u and a. The systems of equations were solved by the method of least squares, which is in the present case easy to use. To the polar stars was attributed a relative weight of 0.25, in accordance with their probable errors. The azimuth (a) being found the individual clock corrections were derived also for each star separately. The collimation corrections are given above on page 8, 9. The method of observation was in April, May, October and November one of registering with a chronograph, and in August, September it was the eye-ear method. The constant of lateral flexure was taken in October, November as — $0^s.15_5$, but in April, May the round value — $0^s.16$ was used; in August and September the constant was taken equal to — $0^s.19_5$ (see page 7).

Star	Adopted right ascension	Observed transit time	Calculated clock correction

April 13-th 1927.

Clamp east; $i = +0^{s}.145$ (west higher)

1 Leonis	$10^{h}\,45^{m}\,25.^{s}95$	$10^{h}\,45^{m}\,20.^{s}51$	$+6.^{s}07$
β Urs. maj.	10 57 28. 39	10 57 22. 81	6. 25
χ Leonis	11 1 15. 85	11 1 10. 44	6. 05
ψ Urs. maj.	11 5 35. 11	11 5 29. 62	6. 09
δ Leonis	11 10 14. 53	11 10 9. 05	6. 09
σ Leonis	11 17 23. 14	11 17 17. 67	6. 11
λ Drac.	11 27 8. 29	11 27 3. 13	(6. 05)[1]
β Leonis	11 45 21. 13	11 45 15. 63	6. 12
γ Urs. maj.	11 50 1. 63	11 49 56. 13	6. 14
o Virgin.	12 1 30. 36	12 1 24. 83	6. 18
4 H. Drac.	12 8 53. 51	12 8 58. 72	(5. 82)[1]
η Virgin.	12 16 11. 13	(12 16 5. 62)	(6. 16)[2]
20 Comae	12 26 4. 31	12 25 58. 81	6. 12
8 Can. ven.	12 30 18. 12	12 30 12. 75	6. 00

$a = -0.^{s}39_2$ $u = +6.^{s}10_0$
$\pm 0.^{s}01_5$ (p. e.)

April 18-th 1927.

Clamp east; $i = +0.^{s}177$

1 Leonis	$10^{h}\,45^{m}\,25.^{s}91$	$10^{h}\,45^{m}\,20.^{s}80$	$+5.^{s}68$
β Urs. maj.	10 57 28. 30	10 57 23. 08	5. 82
χ Leonis	11 1 15. 82	11 1 10. 70	5. 70
ψ Urs maj.	11 5 35. 05	11 5 29. 89	5. 71
δ Leonis	11 10 14. 49	11 10 9. 38	5. 65
σ Leonis	11 17 23. 11	11 17 18. 00	5. 70
λ Drac.	11 27 8. 15	11 27 3. 18	(5. 66)[1]
β Leonis	11 45 21. 11	11 45 15. 93	5. 74
γ Urs. maj.	11 50 1. 58	11 49 56. 35	5. 80
o Virgin.	12 1 30. 34	12 1 25. 19	5. 73
4 H. Drac.	12 8 53. 32	12 8 48. 65	(5. 59)[1]
η Virgin.	12 16 11. 12	12 16 6. 05	5. 67
20 Comae	12 26 4. 30	12 25 59. 15	5. 71
8 Can. ven.	12 30 18. 11	12 30 13. 06	5. 60

$a = -0.^{s}35_2$ $u = +5.^{s}70_5$
$\pm 0.^{s}01_3$ (p. e.)

1) Polar stars.
2) Weight 0.25. Observed only on 3 wires.

Star	Adopted right ascension	Observed transit time	Calculated clock correction

April 27-th 1927.

Clamp east; $i = +0^s.078$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
β Leonis	11h 45m 21.s05	11h 45m 16.s78	+4.s87
γ Urs. maj.	11 50 1. 45	11 49 57. 26	4. 91
o Virgin.	12 1 30. 30	12 1 26. 11	4. 81
4 H. Drac.	12 8 52. 90	12 8 49. 14	(5. 19)1)
η Virgin.	12 16 11. 10	12 16 6. 92	4. 80
8 Can. ven.	12 30 18. 06	12 30 13. 90	4. 81
43 H. Ceph.	0 58 9. 83	12 58 1. 94	(5. 02)1)
43 Comae	13 8 29. 25	13 8 25. 02	4. 87
ζ Urs. maj. pr.	13 21 1. 40	13 20 57. 20	4. 95
ζ Virgin.	13 30 59. 36	13 30 55. 17	4. 81
τ Bootis	13 43 48. 73	13 43 44. 50	4. 84
		$a = -0.^s30_8$	$u = +4.^s86_6$ $\pm 0.^s01_4$ (p. e.)

April 29-th 1927.

Clamp east; $i = +0.^s154$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
β Leonis	11h 45m 21.s04	11h 45m 16.s44	+5.s10
γ Urs. maj.	11 50 1. 42	11 49 56. 81	5. 22
o Virgin.	12 1 30. 29	12 1 25. 76	5. 04
4. H. Drac.	12 8 52. 80	12 8 48. 98	(5. 08)1)
η Virgin.	12 16 11. 09	12 16 6. 64	4. 97
20 Comae	12 26 4. 27	12 25 59. 78	4. 99
8 Can. ven.	12 30 18. 05	12 30 13. 56	5. 03
43 H. Ceph.	0 58 10. 07	12 58 2. 15	(5. 17)1)
43 Comae	13 8 29. 25	13 8 24. 76	5. 00
ζ Urs. maj. pr.	13 21 1. 39	13 20 56. 80	5. 20
ζ Virgin.	13 30 59. 37	13 30 54. 92	4. 97
η Bootis	13 51 13. 68	13 51 9. 16	5. 01
11 Bootis	13 57 53. 17	13 57 48. 71	4. 97
		$a = -0.^s23_0$	$u = +5.^s05_0$ $\pm 0.^s01_7$ (p. e.)

1) Polar stars.

Star	Adopted right ascension	Observed transit time	Calculated clock correction

May 2-nd 1927.

Clamp east; $i = +0.^{s}142$.

4 H. Drac.	12^{h} $8^{m}52.^{s}62$	12^{h} $8^{m}48.^{s}01$	$+(5.^{s}81)$ [1]
η Virgin.	12 16 11. 08	12 16 6. 07	5. 59
20 Comae	12 26 4. 26	12 25 59. 39	5. 43
8 Can. ven.	12 30 18. 02	12 30 13. 20	5. 40
43 H. Ceph.	0 58 10. 41	12 58 2. 50	(5. 57) [1]
43 Comae	13 8 29. 25	13 8 24. 38	5. 43
ζ Urs. maj. pr.	13 21 1. 37	13 21 56. 45	5. 57
ζ Virgin.	13 30 59. 38	13 30 54. 52	5. 44
τ Bootis	13 43 48. 74	13 43 43. 83	5. 47
η Bootis	13 51 13. 69	13 51 8. 77	5. 48
11 Bootis	13 57 53. 18	13 57 48. 23	5. 51
d Bootis	14 7 5. 42	14 7 0. 60	5. 38
[2] α Bootis	14 12 21. 07	14 12 16. 02	5. 61
		$a = -0.^{s}29_{8}$	$u = +5^{s}49_{3}$ $\pm 0.^{s}01_{7}$ (p. e.)

August 8-th 1927.

Clamp east; $i = +0^{s}122$ (west higher).

δ Aquil.	19^{h} $21^{m}51.^{s}12$	19^{h} $19^{m}47.^{s}20$	$+2^{m}4.^{s}79$
β Cygni	19 27 48. 63	19 25 44. 72	2 4. 63
β Sagittae	19 37 48. 23	19 35 44. 49	2 4. 55
γ Aquil.	19 42 49. 40	19 40 45. 48	2 4. 77
α Aquil.	19 47 15. 39	19 45 11. 51	2 4. 72
γ Sagittae	19 55 32. 68	19 53 28. 82	2 4. 68
$\varkappa$ Cephei	20 11 28. 03	20 9 24. 20	(2 4. 93) [1]
γ Cygni	20 19 38. 71	20 17 34. 75	2 4. 75
41 Cygni	20 26 26. 87	20 24 23. 05	2 4. 62
β Delph.	20 34 9. 65	20 32 5. 84	2 4. 63
δ Delph.	20 40 5. 16	20 38 1. 28	2 4. 70
220 H[1] Drac.	20 51 3. 79	20 49 0. 50	(2 4. 54) [1]
ξ Cygni	21 2 18. 79	21 0 15. 00	2 4. 60
α Equul.	21 12 12. 64	21 10 8. 80	2 4. 69
		$a = -0.^{s}57_{6}$	$u = +2^{m}4.^{s}67_{9}$ $\pm 0.^{s}01_{6}$ (p. e.)

1) Polar stars.
2) with a weight of 0.50.

August 9-th 1927.

Clamp east; $i = +0.^s174$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
δ Aquil.	$19^h 21^m 51.^s 12$	$19^h 19^m 41.^s 74$	$+2^m 10.^s 28$
β Cygni.	19 27 48. 63	19 25 39. 13	2 10. 29
β Sagittae	19 37 48. 23	19 35 38. 84	2 10. 21
γ Aquil.	19 42 49. 40	19 40 40. 03	2 10. 23
α Aquil.	19 47 15. 39	19 45 6. 04	2 10. 21
γ Sagittae	19 55 32. 68	19 53 23. 27	2 10. 24
ϰ Cephei	20 11 27. 98	20 9 18. 60	(2 10. 15)[1]
γ Cygni	20 19 38. 71	20 17 29. 24	2 10. 23
41 Cygni	20 26 26. 87	20 24 17. 46	2 10. 20
β Delph.	20 34 9. 65	20 32 0. 30	2 10. 19
δ Delph.	20 40 5. 16	20 37 55. 86	2 10. 13
220 H[1]. Drac.	20 51 3. 76	20 48 54. 62	(2 10. 00)[1]
ξ Cygni	21 2 18. 79	21 0 9. 41	2 10. 14
α Equul.	21 12 12. 64	21 10 3. 30	2 10. 22

$a = -0.^s65_1$ $u = +2^m 10.^s 20_7 \pm 0.^s 01_0$ (p. e.)

August 10-th 1927.

Clamp west; $i = +0.^s036$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
β Cygni	$19^h 27^m 48.^s 62$	19^h 25 31. 22	$+2$ $17.^s 14$
β Sagittae	19 37 48. 22	19 35 31. 04	2 17. 05
γ Aquil.	19 42 49. 40	19 40 32. 27	2 17. 08
α Aquil.	19 47 15. 39	19 44 58. 19	2 17. 17
γ Sagittae	19 55 32. 67	19 53 15. 49	2 17. 14
ϰ Cephei	20 11 27. 94	20 9 7. 12	(2 17. 23)[1]
γ Cygni	20 19 38. 71	20 17 21. 13	2 17. 08
41 Cygni	20 26 26. 87	20 24 9. 47	2 17. 10
β Delph.	20 34 9. 65	20 31 52. 51	2 17. 05
δ Delph.	20 40 5. 16	20 37 48. 01	2 17. 04
220 H[1]. Drac.	20 51 3. 72	20 48 42. 02	(2 16. 96)[1]
ξ Cygni	21 2 18. 79	21 0 1. 10	2 17. 10
α Equul.	21 12 12. 65	21 9 55. 55	2 17. 12
1 Pegasi	21 18 44. 71	21 16 27. 52	2 17. 04

$a = -0.^s61_1$ $u = +2^m 17.^s 08_8 \pm 0.^s 00_9$ (p. e.)

1) Polar stars.

August 15-th 1927.

Clamp west; $i = +0.^s098$.

Star	Adopted right ascension	Observed transit time	Calculated clock correction
β Cygni	$19^h\ 27^m\ 48.^s58$	$19^h\ 25^m\ 4.^s66$	$+2^m 43.^s48$
β Sagittae	19 37 48. 21	19 35 4. 49	2 43. 40
γ Aquil.	19 42 49. 38	19 40 5. 70	2 43. 45
α Aquil.	19 47 15. 37	19 44 31. 82	2 43. 33
γ Sagittae	19 55 32. 65	19 52 48. 90	2 43. 42
$\varkappa$ Cephei	20 11 27. 67	20 8 40. 69	(2 43. 43) 1)
γ Cygni	20 19 38. 68	20 16 54. 47	2 43. 56
41 Cygni	20 26 26. 86	20 23 42. 88	2 43. 50
β Delph.	20 34 9. 65	20 31 25. 93	2 43. 45
δ Delph.	20 40 5. 16	20 37 21. 50	2 43. 39
220 H^1 Drac.	20 51 3. 52	20 48 15. 50	(2 43. 36) 1)
ξ Cygni	21 2 18. 80	20 59 34. 58	2 43. 48
α Equul.	21 12 12. 68	21 9 29. 10	2 43. 40
1 Pegasi	21 18 44. 73	21 16 0. 96	2 43. 44
	$a = -0^s41_9$		$u = +2^m 43.^s44_0$ $\pm 0.^s01_0$ (p. e.)

September 1-st 1927.

Clamp east; $i = +0.^s283$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
π^2 Cygni	$21^h\ 44^m\ 8.^s18$	$21^h\ 39^m\ 50.^s42$	$+4^m 18.^s28$
79 Drac.	21 52 0. 56	21 47 42. 62	4 18. 30
20 Cephei	22 2 50. 40	21 58 32. 76	4 18. 05
24 Cephei	22 8 28. 65	22 4 10. 93	4 18. 00
3 Lacert.	22 20 43. 85	22 16 26. 10	4 18. 24
α Lacert.	22 28 19. 46	22 24 1. 80	4 18. 17
10 Lacert.	22 36 1. 34	22 31 43. 85	4 18. 07
η Pegasi	22 39 36. 97	22 35 19. 53	4 18. 09
	$a = -0.^s64_5$		$u = +4^m 18.^s15_0$ $\pm 0.^s02_7$ (p. e.)

Clamp west; $i = +0.^s198$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
72 Pegasi	$23^h\ 30^m\ 21.^s98$	$23^h\ 26^m\ 3.^s37$	$+4^m 18.^s10$
$\varkappa$ Androm.	23 36 50. 91	23 32 32. 12	4 18. 00
41 H. Ceph.	23 44 28. 27	23 40 8. 16	4 18. 05
ω Piscium	23 55 35. 88	23 51 17. 50	4 18. 23
22 Androm.	0 6 33. 68	0 2 14. 75	4 18. 08
σ Androm.	0 14 32. 83	0 10 14. 10	4 18. 11
44 Piscium	0 21 41. 70	0 17 23. 46	4 18. 13
21 Cassiop.	0 40 52. 66	0 36 31. 31	4 18. 19
	$a = -0.^s50_0$		$u = +4^m 18.^s10_8$ $\pm 0.^s01_7$ (p. e.)

1) Polar stars.

September 3-rd 1927.

Clamp west; $i = +0.168$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
π^2 Cygni	$21^h 44^m 8.^s17$	$21^h 39^m 37.^s63$	$+4^m 29.^s55$
79 Drac.	21 52 0. 50	21 47 28. 32	4 29. 53
20 Cephei	22 2 50. 37	21 58 19. 47	4 29. 45
24 Cephei	22 8 28. 62	22 3 56. 93	4 29. 35
3 Lacert.	22 20 43. 85	22 16 13. 22	4 29. 56
α Lacert.	22 28 19. 46	22 23 48. 95	4 29. 57
10 Lacert.	22 36 1. 35	22 31 31. 30	4 29. 39
η Pegasi	22 39 36. 98	22 35 7. 04	4 29. 35
		$a = -0.^s21_1$	$u = +4^m 29.^s46_1$ $\pm 0.^s02_2$ (p. e.)

Clamp east; $i = +0.^s345$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
4 Cassiop.	$23^h 21^m 38.^s48$	$(23^h 17^m 9.^s58)$[1]	$+(4^m 29.^s24)$
72 Pegasi	23 30 22. 01	23 25 53. 04	4 29. 33
$\varkappa$ Androm.	23 36 50. 94	23 32 21. 91	4 29. 36
41 H. Ceph.	23 44 28. 31	23 39 59. 23	4 29. 43
ω Piscium	23 55 35. 91	23 51 6. 99	4 29. 35
22 Androm.	0 6 33. 72	(0 2 4. 71)[1]	(4 29. 34)
σ Androm.	0 14 32. 88	0 10 3. 81	4 29. 42
44 Piscium	0 21 41. 75	0 17 12. 86	4 29. 34
		$a = -0.^s26_3$	$u = +4^m 29.^s37_3$ $\pm 0.^s01_3$ (p. e.)

October 10-th 1927.

Clamp west; $i = +0.^s197$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
β Androm.	$1^h 5^m 41.^s12$	$1^h 5^m 43.^s14$	$-2.^s59$
ζ Piscium	1 9 57. 44	1 9 59. 93	2. 65
v Piscium	1 15 29. 65	1 15 31. 87	2. 64
38 Cassiop.	1 25 51. 22	1 25 51. 64	(2. 74)[2]
v Persei	1 33 33. 30	1 33 35. 03	2. 64
φ Persei	1 39 7. 77	1 39 9. 49	2. 70
50 Cassiop.	1 57 15. 59	1 57 15. 44	(2. 48)[2]
4 Urs. min.	14 9 0. 76	2 9 7. 83	(2. 60)[2]
o Ceti	2 15 41. 86	2 15 44. 47	2. 67
ξ^2 Ceti	2 24 18. 99	2 24 21. 46	2. 54
ν Ariet.	2 34 42. 62	2 34 44. 80	2. 53
θ Persei	2 39 15. 55	2 39 17. 12	2. 50
		$a = -0.^s49_8$	$u = -2.^s60_6$ $\pm 0.^s01_3$ (p. e.)

1) Corresponding weights of 0.5 and 0.25; observations on few wires.
2) Polar stars.

October 15-th 1927.

Clamp east; $i = +0.^s299$

Star	Adopted right ascension	Observed transit time	Calculated clock correction
ζ Androm.	$0^h\ 43^m\ 30.^s51$	$0^h\ 43^m\ 31.^s72$	$-0.^s58$
μ Androm.	0 52 44. 55	0 52 45. 58	0. 50
ε Piscium	0 59 11. 68	0 59 12. 91	0. 60
β Androm.	1 5 41. 15	1 5 42. 32	0. 62
ζ Piscium	1 9 57. 47	1 9 58. 70	0. 50
υ Piscium	1 15 29. 69	1 15 30. 72	0. 45
38 Cassiop.	1 25 51. 30	(1 26 1. 52) ?	—
υ Persei	1 33 33. 36	1 33 34. 30	0. 48
φ Persei	1 39 7. 84	1 39 8. 80	0. 50
50 Cassiop.	1 57 15. 72	1 57 16. 07	(0. 18) [1]
4. Urs. min.	14 9 0. 61	2 9 1. 90	(0. 34) [1]
o Ceti	2 15 41. 93	2 15 43. 31	0. 58
ξ^2 Ceti	2 24 19. 06	2 24 20. 31	0. 52
ν Ariet.	2 34 42. 70	2 34 43. 86	0. 52
θ Persei	2 39 15. 67	2 39 16. 72	0. 59
		$a = -0.^s61_9$	$u = -0.^s52_9$
			$\pm 0.^s01_3$ (p. e.)

October 16-th 1927.

Clamp west; $i = -0.^s055$ (east higher).

The inclination is changed; possible changes in azimuth.

Star	Adopted right ascension	Observed transit time	Calculated clock correction
ζ Androm.	$0^h\ 43^m\ 30.^s51$	$0^h\ 43^m\ 30.^s41$	$-0.^s09$
μ Androm.	0 52 44. 55	0 52 44. 38	0. 19
ε Piscium	0 59 11. 69	0 59 11. 80	0. 16
β Androm.	1 5 41. 16	1 5 41. 00	0. 15
ζ Piscium	1 9 57. 47	1 9 57. 60	0. 18
υ Piscium	1 15 29. 69	1 15 29. 60	0. 14
38 Cassiop.	1 25 51. 31	1 25 49. 94	(0. 16) [1]
υ Persei	1 33 33. 37	1 33 33. 01	0. 19
φ Persei	1 39 7. 86	1 39 7. 41	0. 14
4 Urs. min.	14 9 0. 57	2 9 4. 08	(0. 15) [1]
o Ceti	2 15 41. 94	2 15 42. 10	0. 15
ξ^2 Ceti	2 24 19. 08	2 24 19. 14	0. 12
36 H. Cass.	2 31 9. 30	2 31 7. 56	(0. 06) [1]
θ Persei.	2 39 15. 69	2 39 15. 27	0. 14
		$a = -0.^s43_5$	$u = -0.^s14_8$
			$\pm 0.^s00_5$ (p. e.)

1) Polar stars.

Star	Adopted right ascension	Observed transit time	Calculated clock correction

October 19-th 1927.

Clamp east; $i = +0.^{s}044$ (west higher).

ζ Androm.	$0^{h}\,43^{m}\,30.^{s}52$	$0^{h}\,43^{m}\,30.^{s}31$	$+0.^{s}99$
μ Androm.	0 52 44. 56	0 52 44. 29	1. 04
ε Piscium	0 59 11. 70	0 59 11. 54	0. 95
β Androm.	1 5 41. 17	1 5 40. 90	1. 04
ζ Piscium	1 9 57. 49	1 9 57. 26	1. 02
v Piscium	1 15 29. 71	1 15 29. 48	0. 96
38 Cassiop.	1 25 51. 33	1 25 51. 23	(1. 10)[1]
v Persei	1 33 33. 39	1 33 33. 16	1. 02
φ Persei	1 39 7. 88	1 39 7. 61	1. 01
50 Cassiop.	1 57 15. 82	1 57 15. 66	(1. 21)[1]
5 Urs. min.	14 27 34. 41	2 27 33. 04	(1. 17)[1]
		$a = -0.^{s}49_{9}$	$u = +1.^{s}01_{7}$ $\pm 0.^{s}01_{1}$ (p. e.)

October 21-st 1927.

Clamp west; $i = -0.^{s}052$

ζ Androm.	$0^{h}\,43^{m}\,30.^{s}52$	$0^{h}\,43^{m}\,28.^{s}53$	$+1.^{s}86$
μ Androm.	0 52 44. 56	0 52 42. 34	1. 91
ε Piscium	0 59 11. 70	0 59 9. 90	1. 81
β Androm.	1 5 41. 18	1 5 38. 98	1. 93
ζ Piscium	1 9 57. 49	1 9 55. 64	1. 88
v Piscium	1 15 29. 72	1 15 27. 66	1. 90
v Persei	1 33 33. 41	1 33 30. 90	1. 99
φ Persei	1 39 7. 90	1 39 5. 39	1. 91
50 Cassiop.	1 57 15. 85	1 57 12. 01	(2. 04)[1]
4 Urs. min.	14 9 0. 49	2 9 2. 05	(2. 07)[1]
θ Persei	2 39 15. 78	2 39 13. 27	1. 97
ε Arietis	2 55 4. 76	2 55 2. 80	1. 87
		$a = -0.^{s}52_{5}$	$u = +1.^{s}90_{9}$ $\pm 0.^{s}01_{2}$ (p. e.)

1) Polar stars.

Star	Adopted right ascension	Observed transit time	Calculated clock correction
	November 2-nd 1927.		
	Clamp east; $i = +0.^{s}039$		
v Persei	$1^{h}\,33^{m}\,33.^{s}47$	$1^{h}\,33^{m}\,26.^{s}28$	$+8.^{s}02$
φ Persei	1 39 7. 96	1 39 0. 68	8. 10
α Triang.	1 48 57. 82	1 48 50. 61	8. 02
50 Cassiop.	1 57 15. 98	1 57 8. 93	(8. 05) [1]
α Ariet.	2 3 6. 12	2 2 58. 91	8. 02
4 Urs. min.	14 9 0. 44	2 8 52. 23	(8. 14) [1]
ξ^2 Ceti	2 24 19. 25	2 24 12. 23	7. 86
36 H. Cass.	2 31 9. 73	2 31 2. 83	(7. 92) [1]
θ Persei	2 39 15. 97	2 39 8. 78	8. 00
41 Ariet.	2 45 43. 92	2 45 36. 78	7. 95
ε Ariet.	2 55 4. 92	2 54 57. 81	7. 93
α Ceti	2 58 30. 41	2 58 23. 40	7. 87
τ Ariet.	3 17 3. 45	3 16 56. 40	7. 86
	$a = -0.^{s}56_7$		$u = +7.^{s}96_8$ $\pm 0.^{s}01_5$ (p. e.)
	November 21-st 1927. [2]		
	Clamp west; $i = -0.^{s}270$		
v Piscium	$1^{h}\,15^{m}\,29.^{s}72$	$1^{h}\,15^{m}\,10.^{s}81$	$+18.^{s}99$
38 Cassiop.	1 25 51. 11	1 25 31. 17	(18. 96) [1]
v Persei	1 33 33. 43	1 33 14. 28	18. 97
φ Persei	1 39 7. 94	1 38 48. 62	19. 11
α Triang.	1 48 57. 86	1 48 38. 84	19. 10
50 Cassiop.	1 57 15. 90	1 56 55. 63	(19. 10) [1]
	$a = -0.^{s}58_5$		$u = +19.^{s}03_5$ $\pm 0.^{s}01_7$ (p. e.)
	Clamp east; $i = -0.^{s}135$		
36 H. Cass.	$2^{h}\,31^{m}\,9.^{s}89$	$2^{h}\,30^{m}\,52.^{s}20$	$+(19.^{s}26)$ [1]
γ Ceti.	2 39 33. 81	2 39 15. 72	19. 05
41 Ariet.	2 45 44. 09	2 45 25. 89	19. 19
ε Ariet.	2 55 5. 10	2 55 47. 00	19. 08
β Persei	3 3 28. 34	3 3 10. 22	19. 15
ζ Ariet.	3 10 45. 21	3 10 27. 13	19. 05
γ Urs. min.	15 20 45. 53	3 20 26. 06	(19. 24) [1]
	$a = -0.^{s}58_3$		$u = +19.^{s}13_0$ $\pm 0.^{s}01_9$ (p. e.)

1) Polar stars.

2) Observations with a relative weight of 0.5, according to the number of observed wires.

4. Discussion of Results.

The following table gives the results of the longitude determinations for the transit instrument. Since the wireless time signals were received by comparing them with the beats of the *Löbner* clock, they must be reduced to the chronograph in April, May, October and November. The interval between the *Hohwü* clock and the chronograph was determined several times by different methods and following corrections were adopted (including the parallax error $0.^s024$ and the inequality of chronograph seconds): in April, May $+0.^s244$ and in October, November $+0.^s192$. According to **2. 6** the personal error was adopted being zero.

Using the Nauen time signals we must reduce our time determinations, which are calculated by the system of the American Ephemeris, to the system of the Berliner Jahrbuch [1]). The differences between the two systems were derived by comparing the positions of all used stars in both Ephemerids. Therefore the clock corrections derived in the above table (3) must be corrected for Nauen by following quantities: in April, May $+0.^s069$; in August $+0.^s033$; in September $+0.^s068$; in October, November $+0.^s050$.

Such corrections are not necessary for the Eiffel-Tower signals in October and November, when these signals were received here. When the Eiffel signals were not received here, the differences „Greenwich—Hohwü" (determined by the Nauen signals) for the other observations were reduced to the Paris clocks by comparing the moments of the Nauen rhythmic signals received in Paris and published in „Beobachtungs-Zirkulare der Astr. Nachrichten 1927" and in „Bulletin Horaire" Tome II p. 388 and Tome III p. 77. Since the differences between Paris and Hamburg corrections vary rather slowly the simple interpolation was used for the moments of the transit observations. Of course it is quite possible, that there may be systematical differences between the real Eiffel signals and the Nauen signals „reduced to the Paris clocks", depending for example upon local causes.

1) L. Grabowski. Radiotelegraphische Bestimmung der geographischen Länge von Lemberg (Lwów). 1927.

The longitudes by the Nauen signals.

Determined clock corrections reduced to the system of the „Berliner Jahrbuch 1927“.

Chronograph observations.

Date. Position of the instrument	Greenwich— —Hohwü chr.	Clock correction	Longitude
April 13-th E.	$-1^{h}46^{m}46.^{s}96_{4}$	$+6.^{s}16_{9}$	$-1^{h}46^{m}53.^{s}13_{3}$
April 18-th E.	$1\ 46\ 47.\ 34_{4}$	$5.\ 77_{5}$	$1\ 46\ 53.\ 11_{9}$
April 27-th E.	$1\ 46\ 48.\ 22_{4}$	$4.\ 93_{5}$	$1\ 46\ 53.\ 15_{9}$
April 29-th E.	$1\ 46\ 48.\ 04_{4}$	$5.\ 11_{9}$	$1\ 46\ 53.\ 16_{3}$
May 2-nd E.	$1\ 46\ 47.\ 60_{4}$	$5.\ 56_{2}$	$1\ 46\ 53.\ 16_{6}$
			$-1^{h}\ 46^{m}\ 53.^{s}15_{0}$
			$\pm 0.^{s}00_{7}$ (p. e.)

Eye-ear observations.

Date. Position of the instrument	Greenwich— —Ericsson 74	Clock correction	Longitude
August 8-th E.	$-1^{h}44^{m}48.^{s}65_{5}$	$+2^{m}\ 4.^{s}71_{2}$	$-1^{h}46^{m}53.^{s}36_{7}$
August 9-th E.	$1\ 44\ 43.\ 09_{5}$	$2\ 10.\ 24_{0}$	$1\ 46\ 53.\ 33_{5}$
August 10-th W.	$1\ 44\ 36.\ 27_{5}$	$2\ 17.\ 12_{1}$	$1\ 46\ 53.\ 39_{6}$
August 15-th W.	$1\ 44\ \ 9.\ 80_{5}$	$2\ 43.\ 47_{3}$	$1\ 46\ 53.\ 27_{8}$
September 1-st {E,W.}	1 42 35. 04	$\{4\ 18.\ 19_{7}\}$	$1\ 46\ 53.\ 23_{7}$
September 3-rd {W,E}	1 42 23. 69	$\{4\ 29.\ 48_{5}\}$	$1\ 46\ 53.\ 17_{5}$
			$-1^{h}\ 46^{m}\ 53.^{s}29_{8}$
			$\pm 0.^{s}02_{2}$ (p. e.)

Chronograph observations.

Date. Position of the instrument	Greenwich— —Hohwü chr.	Clock correction	Longitude
October 10-th W.	$-1^{h}46^{m}55.^{s}68_{7}$	$-2.^{s}55_{6}$	$-1^{h}46^{m}53.^{s}13_{1}$
October 15-th E.	$1\ 46\ 53.\ 65_{7}$	$-0.\ 47_{9}$	$1\ 46\ 53.\ 17_{8}$
October 16-th W.	$1\ 46\ 53.\ 20_{7}$	$-0.\ 09_{8}$	$1\ 46\ 53.\ 10_{9}$
October 19-th E.	$1\ 46\ 52.\ 11_{7}$	$+1.\ 06_{7}$	$1\ 46\ 53.\ 18_{4}$
October 21-st W.	$1\ 46\ 51.\ 30_{2}$	$+1.\ 95_{9}$	$1\ 46\ 53.\ 26_{1}$
November 2-nd E.	$1\ 46\ 45.\ 21_{2}$	$+8.\ 01_{8}$	$1\ 46\ 53.\ 23_{0}$
November 21-st {W,E}	$1\ 46\ 34.\ 08_{2}$	$\{+19.\ 13_{2}\}$	$1\ 46\ 53.\ 21_{4}$
			$-1^{h}\ 46^{m}\ 53.^{s}18_{6}$
			$\pm 0.^{s}01_{3}$ (p. e.)

The longitudes by the Eiffel signals.

Chronograph observations. The Eiffel signals not received here. The Nauen signals reduced to the Paris clocks.

Date. Position of the instrument	Greenwich— —Hohwü chr.	Clock correction	Longitude
April 13-th E.	$-1^h 46^m 47.^s 04_9$	$+6.^s 10_0$	$-1^h 46^m 53.^s 14_9$
April 18-th E.	$1\ 46\ 47.\ 42_0$	$5.\ 70_5$	$1\ 46\ 53.\ 12_5$
April 27-th E.	$1\ 46\ 48.\ 18_4$	$4.\ 86_6$	$1\ 46\ 53.\ 05_0$
April 29-th E.	$1\ 46\ 0.\ 05_2$	$5.\ 05_0$	$1\ 46\ 53.\ 10_2$
May 2-nd E.	$1\ 46\ 47.\ 64_4$	$5.\ 49_3$	$1\ 46\ 53.\ 13_7$

$-1^h\ 46^m\ 53.^s 11_3$
$\pm 0.^s 01_2$ (p. e.)

Eye-ear observations. The Eiffel signals not received here. The Nauen signals reduced to the Paris clocks.

Date. Position of the instrument	Greenwich— —Ericsson 74	Clock correction	Longitude
August 8-th E.	$-1^h 44^m 48.^s 66_8$	$+2^m\ 4.^s 67_9$	$-1^h 46^m 53.^s 34_7$
August 9-th E.	$1\ 44\ 43.\ 10_3$	$2\ 10.\ 20_7$	$1\ 46\ 53.\ 31_0$
August 10-th W.	$1\ 44\ 36.\ 30_0$	$2\ 17.\ 08_8$	$1\ 46\ 53.\ 38_8$
August 15-th W.	$1\ 44\ 9.\ 79_5$	$2\ 43.\ 44_0$	$1\ 46\ 53.\ 23_5$
September 1-st {E, W}	$1\ 42\ 35.\ 12_2$	$\{4\ 18.\ 12_9\}$	$1\ 46\ 53.\ 25_1$
September 3-rd {W,E}	$1\ 42\ 23.\ 78_2$	$\{4\ 29.\ 41_7\}$	$1\ 46\ 53.\ 19_9$

$-1^h 46^m\ 53.^s 28_8$
$\pm 0.^s 01_9$ (p. e.)

Chronograph observations. The Eiffel signals received at Tartu.

Date. Position of the instrument	Greenwich— —Hohwü chr.	Clock correction	Longitude
October 16-th W.	$-1^h 46^m 53.^s 36_3$	$-0.^s 14_8$	$-1^h 46^m 53.^s 21_5$
October 19-th E.	$1\ 46\ 52.\ 29_3$	$+1.\ 01_7$	$1\ 46\ 53.\ 31_0$
October 21-st W.	$1\ 46\ 51.\ 45_9$	$+1.\ 90_9$	$1\ 46\ 53.\ 36_8$
November 2-nd E.	$1\ 46\ 45.\ 35_2$	$+7.\ 96_8$	$1\ 46\ 53.\ 32_0$
November 21-st {W,E}	$1\ 46\ 34.\ 16_2$	$+\{19.\ 08_2\}$	$1\ 46\ 53.\ 24_4$

$-1^h\ 46^m\ 53^s.29_1$
$\pm 0.^s 01_8$ (p. e.)

The considerable difference between the Nauen and the Eiffel signals in October gives for the longitude of the transit instrument values which differ by about $0.^s1$. But according to Greenwich Observations such differences are quite possible and we can see that the differences vary slowly.

The derived longitudes naturally depend on the adopted longitudes of Hamburg and Paris. From Greenwich Observations 1924. and 1925. we infer that on the average the Paris rhythmic signals were too late in 1924. by $+0.^s081$ and in 1925. by $+0.^s114$ and the Nauen signals correspondingly by $+0.^s004$ and by $+0.^s050$. This may be explained at least partly as errors in corresponding longitudes.

It seems that the east longitude of the Tartu Observatory is according to the Nauen signals several hundreths of a second smaller than given in Albrecht's Compensation. The personal equation is known only for the observations in October and November and so it may be possible that the differences of the other groups of observations may depend partly on the personal equation. But since the mean between the first and the second group of observations does not differ considerably from the third group we will take the mean of all observations, giving to the first and the second group a relative weight of 0.25. We see that in the case of the Eiffel signals we can also take the mean in a similar manner. So we have a p r e l i m i n a r y value for the longitude of the transit circle:

according to the Nauen signals $-1^h\ 46^m\ 53.^s19_9 \pm 0.^s01_1$ (probable error)

according to the Eiffel signals $-1^h\ 46^m\ 53^s.26_0 \pm 0^s.01_7$.

The meridian circle is situated 13.1 meters westward from the transit circle in the same geographical latitude. In our latitude this difference is equal to $0.^s054$ and we find a preliminary value of the longitude of the meridian circle as follows:

according to the Nauen signals $-1^h\ 46^m\ 53.^s14_5 \pm 0.^s01_1$ (p. e.)
according to the Eiffel signals $-1^h\ 46^m\ 53^s.20_6 \pm 0^s.01_7$.

The measures of Pomerantzev and Rylke between Pulkovo and Tartu gave the difference of longitude $-14^m\ 25.^s385 \pm 0.^s014$ [1]). Using the best modern direct wireless longitude determination between Greenwich and Pulkovo by Beljajeff and Dneprovsky,

1) Tartu Publications vol. XXIV part 1. 1914.

the longitude of Pulkovo is —2^h 1^m $18.^s572$ [1]) and therefore the longitude of the Tartu meridian circle is according to Pomerantzev and Rylke —1^h 46^m $53.^s18_7 \pm 0.^s014$.

5. Summary.

1. The preliminary determinations of the longitude of the Tartu Observatory by the wireless was made in 1927 on 18 nights with the old Dollond transit instrument. The derived east longitude of the meridian-circle from Greenwich is
according to the Nauen signals —1^h 46^m $53.^s14_5 \pm 0.^s01_1$ (p. e.)
according to the Eiffel signals —1^h 46^m $53^s.20_6 \pm 0^s.01_7$.

The rather sensible probable error is caused by the systematical differences of the methods used.

2. The derived longitude of Tartu from Greenwich depends on the adopted longitudes of Hamburg (Deutsche Seewarte) and Paris. Using for the longitude of Hamburg (Deutsche Seewarte) the adopted value of —0^h 39^m $53.^s42$ and for the longitude of Paris correspondingly —0^h 9^m $21.^s04$ we have, free from the possible longitude errors of Paris and Hamburg:

Difference of longitude between Hamburg and Tartu (meridian-circle): —1^h 6^m $59.^s72_5 \pm 0.^s01_1$.

Difference of longitude between Paris and Tartu (meridian-circle): —1^h 37^m $32^s.16_6 \pm 0^s01_7$.

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1) Monthly Notices vol. 87 page 649. 1927.