NETHERLANDS GEODETIC COMMISSION
PUBLICATIONS ON GEODESY NEW SERIES
VOLUME 6 NUMBER 1

GEODETIC-ASTRONOMICAL OBSERVATIONS IN THE NETHERLANDS, 1947-1973

by

G. J. HUSTI

1975
RIJKSCOMMISSIE VOOR GEODESIE, KANAALWEG 4, DELFT, NETHERLANDS

PRINTED BY W. D. MEINEMA B.V., DELFT, NETHERLANDS

ISBN 90 6132 222 7

CONTENTS

List of symbols 4

1 Introduction 5

2 Instrument set-ups, reductions to centre, polar motion correction 6

3 Longitude determinations (Leeuwarden, Ameland, Zierikzee, Goedereede) 8

4 Simultaneous latitude, longitude and azimuth determinations (Ubachsberg, Tongeren) 15

5 Azimuth determinations (Goedereede, Zierikzee) 19

6 Misclosures of the Laplace stations 22

References 26

Appendixes

I Data longitude determinations 27

II Data simultaneous latitude, longitude and azimuth determinations 32

III Data azimuth determinations 36

IV Systematic errors in the circle division of the theodolite DKM 3A No. 134824 39

V Covariance-matrix of the coordinates related to the base Amersfoort-Veluwe . . 39

LIST OF SYMBOLS

φ, φ_g	latitude (astronomic or geodetic)
λ, λ_g	longitude (positive west of Greenwich)
A, A_g	azimuth of the reference mark
z	zenith distance (of the star)
a	azimuth (of the star)
q	parallactic angle (of the star)
t	local hour angle (of the star)
t^G	Greenwich hour angle (of the star)
α	apparent right ascension (of the star)
δ	apparent declination (of the star)
ψ	horizontal angle R.M.-star
M	Mean value of the level reading: $M = \frac{1}{2}(l+r)$
M_0	reference position of the bubble (approximately corresponding with a vertical alidade axis)
p	level value per division
UT	Universal Time
LMT	Local Mean Time
$GAST$	Greenwich Apparent Sidereal Time
$\hat{\sigma}$	estimate of standard deviation
β	width of the contact strips of the self-recording micrometer
τ	lost motion of the self-recording micrometer
F_k	distances of the contacts with respect to their centre point
N	number of contacts ($k = 1, 2 \dots N$)
s	number of stars ($i = 1, 2 \dots s$)
n	number of series

GEODETIC-ASTRONOMICAL OBSERVATIONS IN THE NETHERLANDS, 1947–1973

1 Introduction

At the end of the 19th century astronomical observations were carried out in The Netherlands with the object of establishing a reference ellipsoid for the national triangulation. For this purpose latitude and azimuth were determined in 13 first order points, regularly distributed over the network [1]. The methods applied for these determinations were meridian altitudes of stars (latitude) and Polaris observations (azimuth). Starting from the astronomical data obtained in each of these points and using the geodetic data of the network, 13 values for latitude and azimuth were computed for Amersfoort, the central station of the net. The mean of these 13 values was assumed to be the geodetic latitude of Amersfoort and the azimuth Amersfoort–Utrecht [3].

The longitude of Amersfoort, although less important for the ellipsoid, was derived from the longitude of Leiden and from the longitude difference Amersfoort–Leiden, computed from the geodetic data.

The data of Amersfoort obtained in this way are:

$$\begin{aligned} \text{latitude } \varphi &= 52^\circ 09' 22''.178 \\ \text{longitude } \lambda &= -5^\circ 23' 15''.500 \\ \text{azimuth Amersfoort–Utrecht } A &= 248^\circ 35' 19''.891 \end{aligned}$$

Laplace stations for azimuth control were not used in the adjustment of the network. In a small country like The Netherlands this is admissible. The need for Laplace stations came much later, namely after the second world war, when it was decided to readjust the European network as a whole. Three twin Laplace stations were planned in The Netherlands for this purpose, i.e. Leeuwarden–Ameland, Zierikzee–Goedereede and Ubachsberg–Tongeren. The measurements were carried out using the following methods:

1. Longitude determination by meridian transit of stars. Leeuwarden (1947), Ameland (1947), Zierikzee (1949) and Goedereede (1950); see section 3.
2. Simultaneous determination of latitude, longitude and azimuth using the Black method. Ubachsberg (1968), Tongeren (1968); see section 4.
3. Azimuth by Polaris. Goedereede (1969), Zierikzee (1973); see section 5.

In addition some results from older measurements are available:

4. Azimuth by Polaris and some circumpolar stars. Ubachsberg (1893) [2].
5. Determination of the longitude difference Leiden–Ubachsberg (1893) [2].
6. Azimuth by Polaris. Leeuwarden (1897), Ameland (1897), Zierikzee (1897) [1].

A summary of the results of the above mentioned measurements is given in table 1.1.

For the Laplace stations Leeuwarden and Ameland the azimuth determinations of 1897 have to be used. The accuracy of these measurements is satisfactory but there is some doubt about the polar motion correction. According to information received from the Director

Table 1.1 Laplace points in The Netherlands

Laplace point (terrestrial direction)	astronomic quantities	$\hat{\sigma}$	year	method/remark
Leeuwarden (C1902)	$\varphi =$ 53°12′15″.283	0″.075	1897	meridian altitudes (Sterneck)
(Hallum, C1897)	$\lambda = -$ 5°47′23″.850	0″.090	1947	meridian transit (Mayer)
	$A =$ 358°31′57″.632	0″.35	1897	Polaris
				$\hat{\sigma}_{A+\lambda \sin \varphi} = 0''.36$
Ameland (C1897)	$\varphi =$ 53°27′30″.249	0″.026	1897	meridian altitudes (Sterneck)
(Hallum, C1897)	$\lambda = -$ 5°46′56″.550	0″.180	1947	meridian transit (Mayer)
	$A =$ 179°05′52″.922	0″.20	1897	Polaris
				$\hat{\sigma}_{A+\lambda \sin \varphi} = 0''.25$
Goedereede (C1896)	$\varphi \approx$ 51°49′10″			
(Zierikzee, C1896)	$\lambda = -$ 3°58′34″.965	0″.090	1950	meridian transit (Mayer)
	$A =$ 192°43′00″.980	0″.10	1969	Polaris
				$\hat{\sigma}_{A+\lambda \sin \varphi} = 0''.13$
Zierikzee (C1896)	$\varphi =$ 51°39′03″.558	0″.085	1897	meridian altitude (Sterneck)
(Goedereede, C1896)	$\lambda = -$ 3°54′53″.655	0″.090	1949	meridian transit (Mayer)
	$A =$ 12°40′07″.071	0″.15	1973	Polaris
				$\hat{\sigma}_{A+\lambda \sin \varphi} = 0''.17$
Ubachsberg (C1890)	$\varphi =$ 50°50′53″.432	0″.41		
(Tongeren, St.A)	$\lambda = -$ 5°57′04″.320	0″.64	1968	Black ($z \approx 60°$)
	$A =$ 258°15′24″.273	0″.53		
				$\hat{\sigma}_{A+\lambda \sin \varphi} = 0''.17$
Tongeren (St.A)	$\varphi =$ 50°46′55″.775	0″.48		
(Ubachsberg, C1890)	$\lambda = -$ 5°27′48″.570	0″.78	1968	Black ($z \approx 60°$)
	$A =$ 77°52′43″.958	0″.64		
				$\hat{\sigma}_{A+\lambda \sin \varphi} = 0''.20$

of the Polar Motion Service at Mizusawa, Mr. S. YUMI, it is not possible to reduce these old measurements to the Conventional International Origin. This means that the final azimuths of OUDEMANS [1] have to be used. These azimuths are only corrected for the annual periodical polar movement, but do of course not refer to the C.I.O. to be used. In order to gain an insight into the possible effect of polar motion, the remeasurement of the azimuth Zierikzee–Goedereede (1973) is compared with the old measurement of 1897:

azimuth 1897:	12°40′07″.387	$\hat{\sigma}_A = 0''.31$
azimuth 1973:	12°40′07″.071	$\hat{\sigma}_A = 0''.15$
difference	0″.316	

In this case the difference is not significant.

2 Instrument set-ups, reduction to the centre, polar motion correction

All the measurements shown in table 1.1 were carried out from a stable observation pillar. The reference marks were measured with the aid of a lamp, placed at a distance of about 10 km from the instrument set-up. The plane rectangular coordinates of the centres, set-ups and lamps with respect to Amersfoort are given in metres in table 2.1.

Table 2.1

station	X	Y	remarks
Leeuwarden Centre 1902	+ 26894.377	+116668.837	
Leeuwarden pillar 1947	+ 26889.663	+116669.740	longitude 1947
Ameland Centre	+ 26177.206	+144988.000	longitude 1947
Hallum Centre 1897	+ 26532.521	+128260.440	terrestrial line azimuths 1896
Goedereede Centre 1896	− 97314.981	− 36522.587	
Goedereede pillar 1950	− 97309.722	− 36527.121	longitude 1950
Goedereede pillar 2 (1969)	− 97312.179	− 36525.790	azimuth 1969
Goedereede pillar 2 (1973)	− 97312.171	− 36525.778	lamp 1973
Zierikzee Centre 1896	−101897.967	− 55142.050	
Zierikzee pillar 1949	−101891.448	− 55148.254	longitude 1949
Zierikzee lamp 1969	−101904.164	− 55132.481	lamp 1969
Zierikzee perm. mark 12	−101890.412	− 55134.008	azimuth 1973
Ubachsberg Centre 1890	+ 39845.615	−145477.288	
Ubachsberg pillar 1966	+ 39774.286	−145558.665	Black, 1968
Tongeren Centre 1892	+ 5433.487	−152902.284	
Tongeren centre Stat. A	+ 5433.945	−152907.075	
Tongeren pillar 1966	+ 5437.230	−152899.507	Black, 1968

The station *Leeuwarden* is a detached unfinished tower with a flat roof, called Oldenhove. The azimuth from this station to Hallum was determined in 1897 [1]. The longitude determination was carried out on pillar 1947. All results were reduced to centre 1902.

The station *Ameland* is situated on top of a high dune, north-northeast of the village of Nes, locally known as the "grey-dune". An observation pillar was built at the centre of the station. The azimuth determination (1897) to Hallum and the longitude determination (1949) were executed at this pillar.

The station *Ubachsberg* is situated in the holiday resort "Vrouweheide" near the village of Ubachsberg. The original centre 1890 proved to be unsuitable for the Black method because of high trees and therefore a new observation pillar (pillar 1966) was erected at a distance of about 100 metres from the old centre. The tower of Schimmert was used as terrestrial reference mark. The 1968-observations were reduced to the 1890-centre.

The observations at *Tongeren* were carried out on the flat roof of the tower of the "Basilique Notre Dame" from an observation pillar built in 1966. The terrestrial reference mark used was a lamp placed on the tower of Herderen. The measurements of 1968 were reduced to centre A.

The station *Zierikzee* is the "St. Lievens Monster", a detached unfinished tower. The observations for the longitude determination (1949) were carried out on pillar 1949. The azimuth measurement (1973) was done from permanent mark 12. For the measurement of the azimuth from Goedereede a lamp was placed on this tower. The results were reduced to centre 1896.

The station *Goedereede* is also a detached unfinished tower. The longitude measurement (1949) were performed on pillar 1949, the azimuth determination (1969) from pillar 2. A lamp was placed on pillar 2 for the azimuth determination from Zierikzee. The results were reduced to centre 1896.

The latitude, longitude and azimuth of an excentric set-up were reduced to the centre applying bearing and distance computed from the coordinates of table 2.1. An example of a reduction is given in [7, p. 17].

The polar motion corrections to the final results were applied using the following formulae:

$$\Delta\varphi'' = -(x\cos\lambda + y\sin\lambda)$$

$$\Delta\lambda'' = -(x\sin\lambda - y\cos\lambda)\tan\varphi$$

$$\Delta A'' = (x\sin\lambda - y\cos\lambda)\sec\varphi$$

in which x and y are coordinates of the true pole (in seconds of arc) referring to the Conventional International Origin. The data for x and y have been taken from publications of the Bureau International de l'Heure (Paris) or from publications of the International Polar Motion Service (Mizusawa).

3 Longitude determinations (Leeuwarden, Ameland, Zierikzee, Goedereede)

3.1 *Introduction*

Longitude determinations were carried out in the stations Leeuwarden (1947), Ameland (1947), Zierikzee (1949) and Goedereede (1950). The results of Goedereede are included in the present report while the measurements of the other stations were already reported in 1950 by Bruins [5]. However, at that time the definite time corrections and polar motion corrections were not available yet. Applying these corrections the longitude changes by about $0^s.040$, an amount which may not be neglected. In this section a brief description of the measurements and the computations will be given.

3.2 *The method used*

The longitude determination is based on the relation:

$$\lambda = GMT - LMT \qquad (3.1)$$

in which:

GMT = Greenwich Mean Time; to be determined from radio time signals
LMT = Local Mean Time; to be determined from meridian-transits of stars.

In the present terminology UT (Universal Time) is used instead of GMT.

Hence we have:

$$\lambda = UT1 - LMT1 = (UT1 - T) - (LMT1 - T) \qquad (3.2)$$

in which the indices 1 mean that both times are related to the Conventional International Origin (C.I.O.).

In formula (3.2) two chronometer corrections are in fact required. They are determined independently but obviously referring to the same moment (T). The chronometer corrections

$(UT1-T)$ were determined by rhythmic time signals of the radio stations Pontoise (FYP) or Rugby (GBR) with an accuracy of about $0^s.001$. Applying some corrections we then obtain:

$$(UT1-T) = (\text{Signal}-T)+\Delta T_d+(UT0_{\text{Paris}}-\text{Signal})+(UT1-UT0_{\text{Paris}}) \quad . \quad (3.3)$$

in which:

$(\text{Signal}-T)$ = chronometer correction determined by the radio time signals; usually referring to the moment of receiving the time signals before the measurement (FYP at $GMT = 20^h06^m$ or GBR at $GMT = 20^h00^m$).

ΔT_d = time correction due to the travel time of the radio signal (Leeuwarden and Ameland $0^s.005$, Goedereede and Zierikzee $0^s.004$).

$(UT0_{\text{Paris}}-\text{Signal})$ = definite time correction according to the Bureau International de l'Heure.

$(UT1-UT0_{\text{Paris}})$ $= \frac{1}{15}(x'' \sin\lambda_{\text{Paris}} + y'' \cos\lambda_{\text{Paris}}) \tan\varphi_{\text{Paris}} \approx -0.076y''$.

The latter corrections were computed in accordance with a suggestion made by Mr. B. Guinot, Director of the Bureau International de l'Heure in Paris. The polar coordinates x, y with respect to the C.I.O. were taken from the "Publications of the International Latitude Observatory of Misusawa" (Vol. VII, No. 1, 1969).

The other chronometer corrections in formula (3.2), $(LMT1-T)$ were determined by meridian transits of stars using Mayer's formula. In case of upper culmination of stars this formula reads:

$$\alpha = T+\Delta T + \frac{\sin(\varphi-\delta)}{\cos\delta}a \pm \frac{\cos(\varphi-\delta)}{\cos\delta}b \pm \frac{1}{\cos\delta}c \begin{pmatrix}+\text{eye piece east}\\ -\text{eye piece west}\end{pmatrix} . \quad . \quad (3.4)$$

in which:

φ = latitude of the station
α = apparent right ascension of the star
δ = apparent declination of the star
T = chronometer time observed
ΔT = chronometer correction $(LMT0-T)$
a = deviation of the line of sight from the meridian
b = inclination of the rotation axis of the telescope
c = collimation error

From the relation (3.4) the following observation equations are obtained:

$$\underline{\Delta T} + \frac{\sin(\varphi-\delta_i)}{\cos\delta_i}\underline{a} \pm \frac{\cos(\varphi-\delta_i)}{\cos\delta_i}\underline{b} \pm \frac{1}{\cos\delta_i}\underline{c} = (\alpha_i - \underline{T}_i)+\varepsilon_i \quad . \; . \; . \; . \; . \; . \; . \quad (3.5)$$

$i = 1, 2, \ldots s$ (= number of stars).

from which a number of unknowns ($\underline{\Delta T}$, $\underline{a}$, $\underline{b}$, $\underline{c}$) can be determined by the method of the least squares. It should be noted that for each group of stars observed in the same instrument position, different unknowns for the deviation of the line of sight from the meridian are introduced. In this way we have:

a_1 : for the first group of stars observed with eye-piece east;
a_{23}: for the second and third group observed with eye-piece west;
a_4 : for the fourth group of stars observed with eye-piece east.

The observation vector $(\alpha_i - T_i)$ in (3.5) is derived from the right ascension of the star and the time observed. Since a mean time chronometer was used, the right ascension was converted into mean time: $\alpha = LAST \rightarrow LMT$, in which $LAST$ denotes Local Apparent Sidereal Time and LMT Local Mean Time. LMT refers to the momentaneous pole, therefore, similar to $UT0$, we can write $LMT0$. In fact, we determine from the adjustment the chronometer correction $(LMT0 - T)$. Applying the polar motion correction to the longitude according to section 2 we then obtain:

$$(LMT1 - T) = (LMT0 - T) + (x \sin\lambda - y \cos\lambda) \tan\varphi$$

To the observed star's transit time some corrections were applied (omitting the index i):

$$T = \overline{T} + N + G \qquad (3.6)$$

in which $\overline{T}$ is the mean value of contact-times resulting from the self-recording micrometer, N and G are respectively corrections for the inclination of the horizontal axis and for the rate of the chronometer used.

The mean value $\overline{T}$ is obtained from:

$$\overline{T} = \frac{1}{N}[T_k + (F_k + \tfrac{1}{2}\tau)C] \qquad k = 1, 2, \ldots N \qquad (3.7)$$

in which:

N = number of contacts used ($N = 36$)
T_k = contact times
F_k = wire distances with respect to the centre wire (or collimation point)
τ = lost motion of the micrometer
C = $7^s.831$ (one revolution of the self-recording micrometer).

It should be noted that the correction for the (different) widths of the 12 contact strips of the micrometer is eliminated by taking the same end of the marks on the chronograph tape.

The correction N in (3.6) was computed from levelling the horizontal axis with the suspension level:

$$N = \frac{\cos(\varphi - \delta)}{\cos\delta}(M_0 - M)p^s$$

in which:

M_0 = reference position of the bubble ($M_0 = 30$)
M = $\tfrac{1}{2}(l + r)$: mean value of the level reading
p^s = $0^s.114$: level value per division

Finally the correction G in (3.6) is computed from:

$$G = (\bar{T} - T_0)\Delta_1 T$$

in which:

$\bar{T}$ = the moment of observation

T_0 = reference moment (usually $GMT = 20^h00^m$ or 20^h06^m before starting the measurements)

$\Delta_1 T$ = chronometer rate (sec/hour); determined from time signals for a period of 12^h or 14^h (see appendix I). Pontoise (FYP): $18^h \rightarrow 8^h$ (next day); Rugby (GBR): $18^h \rightarrow 10^h$ (next day).

Another remark should be made about the method of least square adjustment applied to the observation equations (3.5). In this adjustment different weights were used depending on the declination of the stars, see table 3.2.1. The data of this table were taken from a publication of the U.S. Coast and Geodetic Survey [6].

Table 3.2.1

δ	g
0°	1
10	1
20	0.98
30	0.91
40	0.82
45	0.76
50	0.69
55	0.61
60	0.51
65	0.40
70	0.29
75	0.18
80	0.09

3.3 *Instruments*

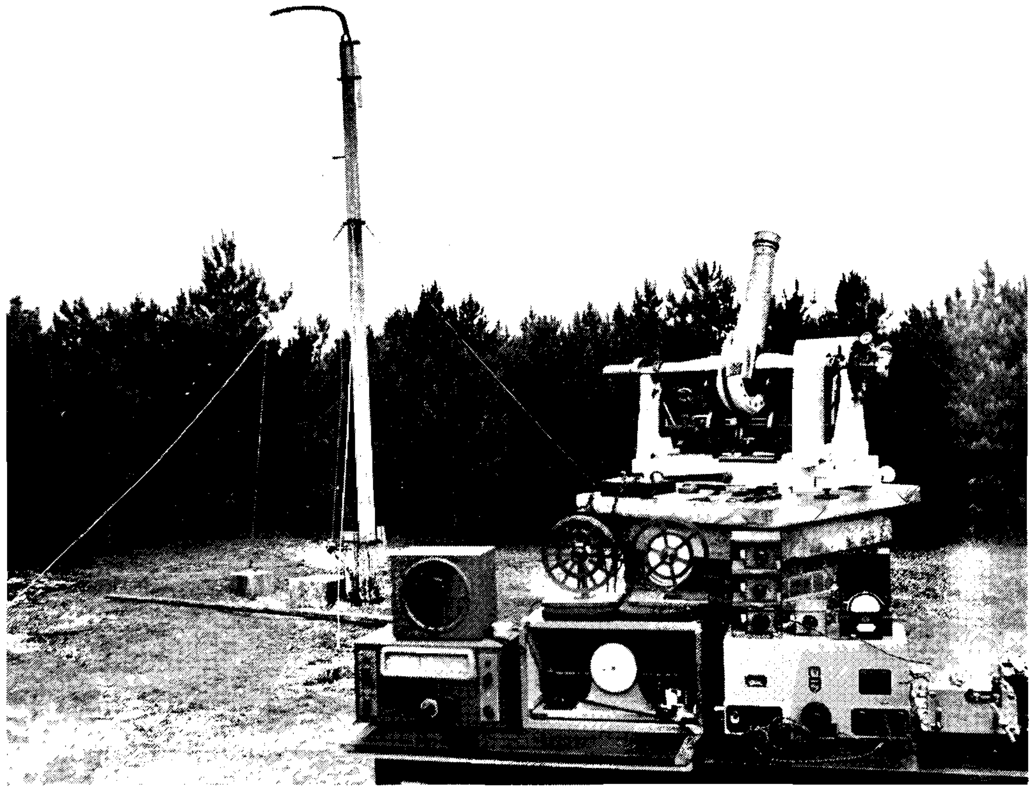
The observations were made using the following equipment:

a. transit instrument
b. chronograph
c. synchron clocks (2)
d. radio receiver

The meridian transits of stars were observed by a transit instrument of an usual type. This instrument was made in 1869 by Pistor and Martins. The technical data are as follows:

Telescope: magnification 85 ×
aperture 67.8 mm
focal length 861 mm

Suspension level: sensitivity $0^s.114$ per division



Transit instrument and time recording equipment used for longitude determination. Pictures show set-up at Ameland.

Self-recording micrometer:

graduation per revolution:	100 divisions
value of one revolution:	$7^s.831$
number of contacts:	12
widths of contact strips:	variable
lost motion:	0.26 div.

The time observations were recorded by an analogue tape chronograph made by the Great Northern Telegraph Cy, Copenhagen. The tape speed of this chronograph is about 24 mm/sec. One pen recorded the observations, the other pen fixed the time scale kept by a quartz clock of the Radio Laboratory of the Post and Telegraph Office in The Hague. The connection between the astronomical station in question and the quartz clock in The Hague was realised by means of a telegraph line. One synchron clock on the astronomical station displayed the time, the other one produced second pulses for the chronograph.

In order to determine the chronometer corrections before and after the measurements, a radio receiver was used for the time signals of the radio stations Pontoise (FYP) or Rugby (GBR).

3.4 *Observations*

In order to obtain an optimal accuracy, a theoretical investigation was carried out with various models of star-programmes. One model consisted of 3 north and 3 south stars in meridian transit having different zenith distances. The weight coefficients of the unknowns (ΔT) and (a) were computed and presented in a nomogram [5]. Based on this nomogram the following method of star selection was applied.

One measuring programme consisted in general of 24 stars, observed in 4 groups. The first group of 6 stars was measured with instrument position eye-piece east, the second and the third groups with eye-piece west, and finally the last one with eye-piece east again. In each group 4 north stars were selected with $\delta \approx 68°$ and 2 south stars with $\delta \approx 23°$, all in upper culmination. Only at the station Zierikzee 4×8 stars were measured, with an equal number of north and south stars.

Each star was tracked over 3 revolutions by the self-recording micrometer of the transit instrument used, while 3×12 contact times were registered on the chronograph.

The observations and different quantities computed are shown in appendix I, in which:

column 1: FK4 number of the stars observed
2: instrument position, eye-piece east or west
3: mean value of suspension level reading (zero of the level always on the opposite side of the eye-piece)
4: the mean time $\overline{T}$, reduced according to formula (3.7)
5: estimate of standard deviation of the mean time $\overline{T}$
6: observation vector $(\alpha - T)$
7: weights, used in the adjustment.

3.5 *Results of the longitude determinations*

The definite results of the adjustment applying the formulae of section 3.2 are shown in

Table 3.5.1

station: Leeuwarden		
date: 1947	longitude	$\hat{\sigma}_\lambda$
May 28–29	$-0^h23^m09^s.568$	$0^s.012$
29–30	$9^s.578$	$0^s.007$
30–31	$9^s.586$	$0^s.014$
31–1	$9^s.559$	$0^s.012$
mean value (pillar 1947)	$-0^h23^m\ 9^s.573$	$0^s.006$
reduction to centre	$-$ $0^s.017$	
Centre 1896	$0^h23^m09^s.590$	$0^s.006$

Table 3.5.2

station: Ameland		
date: 1947	longitude	$\hat{\sigma}_\lambda$
June 16–17	$-0^h23^m07^s.799$	$0^s.017$
17–18	$07^s.746$	$0^s.015$
18–19	$07^s.766$	$0^s.014$
24–25	$07^s.743$	$0^s.019$
25–26	$07^s.795$	$0^s.014$
mean value (centre 1896)	$-0^h23^m07^s.770$	$0^s.012$

Table 3.5.3

station: Goedereede		
date: 1950	longitude	$\hat{\sigma}_\lambda$
June 6–7	$-0^h15^m54^s.290$*	$0^s.020$
15–16	$54^s.352$	$0^s.011$
28–29	$54^s.353$	$0^s.008$
29–30	$54^s.346$	$0^s.013$
mean value (pillar)	$-0^h15^m54^s.350$	$0^s.006$
reduction to centre 1896	$+$ $0^s.019$	
Centre 1896	$-0^h15^m54^s.331$	$0^s.006$

* rejected

Table 3.5.4

station: Zierikzee		
date: 1949	longitude	$\hat{\sigma}_\lambda$
Sept. 12–13 (I)	$-0^h15^m39^s.620$	$0^s.010$
19–20 (I)	$39^s.630$*	$0^s.017$
19–20 (II)	$39^s.582$	$0^s.012$
20–21 (I)	$39^s.607$	$0^s.008$
20–21 (II)	$39^s.593$	$0^s.008$
Oct. 4–5 (I)	$39^s.612$	$0^s.009$
4–5 (II)	$39^s.587$	$0^s.006$
mean value (pillar 1949)	$-0^h15^m39^s.600$	$0^s.006$
reduction to centre	$+$ $0^s.023$	
Centre 1896	$-0^h15^m39^s.577$	$0^s.006$

tables 3.5.1–3.5.4. The small differences, approximately $0^s.040$, with the results of BRUINS [5] are due to definite time corrections and polar motion corrections now applied (see section 3.1).

The homogeneity of the variances of the different nights was investigated using the Bartlett-test [11]. Based on this test all the results of the stations Leeuwarden and Ameland are acceptable. However the measurements of the second night at the station Zierikzee and those of the first night at Goedereede differ considerably from the rest and should be rejected. Rejection of the measurement of the second night at Zierikzee has no serious consequences because of the large number of observations made. At this station namely, two different star programmes were measured, spread over several nights. However a systematic difference between star programmes (I) and (II), is noted. This may be explained by the influence of the different star selection, i.e. the correlation of the time with the other unknowns.

Rejecting the first measurement at Goedereede is also justified by the fact that just before starting these observations troubles were experienced with the optical part of the telescope. However, with great pains the observer succeeded in rectifying this trouble but it might have had a negative effect on the quality of his work that same night.

The mean values of the longitude per station were computed without the observations rejected. The external accuracy of the mean value is computed from the spread of the adjusted values. An exception is made with the station Goedereede: instead of $0^s.002$ obtained in this way a value of $0^s.006$ is taken, derived from the precisions of the longitude.

4 Simultaneous latitude, longitude and azimuth determinations (Ubachsberg, Tongeren)

In the summer of 1968 geodetic-astronomical observations were carried out at the primary stations Ubachsberg (The Netherlands) and Tongeren (Belgium). The latitude, longitude and azimuth were simultaneously determined applying the Black method. The equipment used was an universal theodolite Wild T4 and an Omega timerecorder. The method of computation is briefly described below; more details are given in a previous paper [7].

With the Black method a number of stars are observed in vertical transit. For theoretical and practical reasons the stars are selected at approximately equal zenith distances (in this case $z \approx 60°$) and regularly distributed in azimuth. The observation equations of the Black method read:

$$\underline{\Delta\varphi} \sin a_i \cot z_i + \underline{\Delta\lambda \cos \varphi_0} \cos a_i \cot z_i - \underline{(\Delta A + \Delta\lambda \sin \varphi_0)} = l_i + \varepsilon_i \quad \ldots \quad (4.1)$$

in which the quantities $\Delta\varphi$, $\Delta\lambda \cos \varphi_0$ and $(\Delta A + \Delta\lambda \sin \varphi_0)$ are considered as unknowns. The following relations exist between the approximate values of the latitude, longitude and azimuth and the unknowns:

$$\left.\begin{aligned} \varphi &= \varphi_0 + \Delta\varphi \\ \lambda &= \lambda_0 + \Delta\lambda \\ A &= A_0 + \Delta A \end{aligned}\right\} \quad \ldots \quad (4.2)$$

The observation vector l_i in equation (4.1) is computed from:

$$l_i = A_0 + \psi_i - a_i \quad \ldots \quad (4.3)$$

in which ψ_i is the horizontal angle measured between the terrestrial reference mark (R.M.) and the star in question, and a_i the azimuth of the star computed from the time observed. In case of a number of series per star, observed in face left and face right of the instrument, the mean value of the observation vector and the mean value of the coefficients of the unknowns is used in (4.1).

The horizontal angle ψ_i in (4.3) is obtained by applying some corrections:

$$\psi = \psi' - R(\psi') \pm p(M - M_0) \cot z + \Delta a_A + (C_1' + C_2') \frac{[F_k^2]}{2N\varrho''} \quad \ldots \quad (4.4)$$

in which

- ψ' = the horizontal angle measured (circle reading: Star – R.M.)
- $R(\psi')$ = periodical horizontal circle error of the angle ψ', computed from the circle readings (φ) according to [7]
- p = level value; No. 434: $p = 1''.03$ (if zero of the level on the eye-piece side, the upper sign refers to face left, the lower sign to face right)

M $= \frac{1}{2}(r+l)$ mean value of the suspension level reading
M_0 = reference position of bubble
Δa_A $= -0''.32 \cos\varphi \,\mathrm{cosec}\, z \cos a$ (=daily aberration)
$\frac{[F_k^2]}{2N\varrho''}$ $= 0''.043$ instrumental constant obtained with $N=27$ contacts of the self-recording micrometer, in which F_k = distances of the contacts with respect to their centre point in seconds of arc ($k = 1,2,\ldots N$)
C_1' $= (\cos z \tan q + \cot a \tan^2 q)\,\mathrm{cosec}^2 z$
C_2' $= -2\cos z \tan q \,\mathrm{cosec}^2 z$

The factors C_1' and C_2' were derived at the Geodetic Institute of the Delft University of Technology in a similar way as the factors C_1 and C_2 derived by ROELOFS [9] for zenith distance measurement. The factor C_1' corrects the non-linear relation between time and azimuth; C_2' must be applied because all the vertical wires except the central wire (i.e. contacts) are in fact non-vertical great circles.
Meanwhile these factors were compared with a correction formula given by JORDAN-EGGERT-KNEISSL [8], page 440, which is applied as a time correction to the mean value of the contact-times in the following way:

$$\bar{T} = \frac{[T]}{N} + C_t \frac{[F_k^2]}{2N\varrho''}$$

in which $C_t = \frac{1}{15} \tan\delta \sec\delta \tan q \sec^2 q$. In order to correct the star's azimuth instead of the time, this time factor was converted into an azimuth factor.
Multiplying with:

$$\frac{\mathrm{d}a}{\mathrm{d}t} = 15 \cos\delta \cos q \,\mathrm{cosec}\, z$$

gives:

$$C_a = C_t \times \frac{\mathrm{d}a}{\mathrm{d}t} = \tan\delta \tan q \sec q \,\mathrm{cosec}\, z$$

Substituting $\tan\delta = \cot z \cos q - \mathrm{cosec}\, z \sin q \,\mathrm{cosec}\, z$ gives:

$$C_a = (\cos z \tan q - \cot a \tan^2 q)\,\mathrm{cosec}^2 z = -(C_1' + C_2')$$

Hence it can be concluded that the two corrections are exactly identical (the signs are opposite because the correction with the factors $(C_1' + C_2')$ must be applied to the horizontal angle measured).

The star's azimuth used in (4.3) is computed from:

$$\cot a_i = \frac{\sin\varphi_0 \cos(t_i^G - \lambda_0) - \cos\varphi_0 \tan\delta_i}{\sin(t_i^G - \lambda_0)} \quad \ldots\ldots\ldots\ldots\ldots \quad (4.5)$$

in which the Greenwich hour angle t_i^G of the star is determined from the time measurement. To the mean value $\overline{T}$ of the contact times, obtained by tracking the star with the aid of the vertical wire of the self-recording micrometer, some corrections were applied:

$$(UT1) = \overline{T} + (UTC - \overline{T}) + (UT1 - UTC) + \frac{(\beta'' + \tau'')}{2 \times 0.997 \times 15} |\sec\delta \sec q| \quad . \quad . \quad (4.6)$$

in which:

$(UT1)$	= corrected $UT1$
$(UTC - \overline{T})$	= chronometer correction determined by radio time signals (usually MSF/Rugby 5 MHz)
$(UT1 - UTC)$	= correction to the time signal according to the Bureau International de l'Heure
$(\beta'' + \tau'')$	= sum of the width of the contact strips and the lost motion of the self-recording micrometer.

The $(UT1)$ obtained in (4.6) is then converted into Greenwich apparent sidereal time:

$$GAST = (UT1) \times 1.0027379 + GAST(0^h UT) + \Delta e \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (4.7)$$

in which Δe is the change in the equation of equinoxes during the period of UT.

Finally from $GAST$ the Greenwich hour angle to be used is obtained from:

$$t^G = GAST - \alpha \quad . \; . \quad (4.8)$$

The determination of the three unknowns according to the observation equations (4.1) was carried out by least square adjustment. From the observation equations (4.1) written in the form:

$$AX = L + E \quad . \; . \quad (4.9)$$

it follows:

$$X = \begin{pmatrix} \Delta\varphi \\ \Delta\lambda \cos\varphi_0 \\ \Delta A + \Delta\lambda \sin\varphi \end{pmatrix} = (A^*A)^{-1} A^*L = QA^*L \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (4.10)$$

in which Q is approximately a diagonal matrix with elements Q_{11}, Q_{22} and Q_{33}, if the stars are selected at equal zenith distance and regularly distributed in azimuth. The astronomical latitude, longitude and azimuth are then obtained from (4.2).

The estimate of the variance of the observation vector per star follows from:

$$\hat{\sigma}^2 = \frac{E^*E}{s-3} \quad . \; . \quad (4.11)$$

in which E is determined by substituting the unknowns into (4.9). The standard deviations of the unknowns are then:

$$\left.\begin{aligned} \hat{\sigma}_{\varphi} &= \hat{\sigma}\sqrt{Q_{11}} \\ \hat{\sigma}_{\lambda} &= \hat{\sigma}\sqrt{Q_{22}\sec^2\varphi} \\ \hat{\sigma}_{A_g} &= \hat{\sigma}\sqrt{Q_{33}} \\ \hat{\sigma}_{A} &= \hat{\sigma}\sqrt{Q_{44}} \end{aligned}\right\} \quad \ldots\ldots\ldots \quad (4.12)$$

in which A_g denotes the geodetic azimuth: $A_g = A + \Delta\lambda \sin \varphi_0$. The weight coefficient Q_{44} of the astronomical azimuth is computed in the following way:

$$Q_{44} = Q_{33} + Q_{22}\tan^2\varphi - Q_{23}\tan\varphi \quad \ldots\ldots\ldots \quad (4.13)$$

In total 36 stars were observed at the station Ubachsberg and 32 stars at Tongeren in different nights. The observation of one star was made in the following sequence:

face left: reference mark 2 ×
star 2 × tracking over 27 contacts
face right: star 2 ×
reference mark 2 ×

The observations and some additional data are shown in appendix II, in which:

Column 1: date
2: FK4 number of the star observed
3: face: (1) = left; (2) = right
4: horizontal circle reading reference mark
5: horizontal circle reading star
6: mean value of the suspension level reading (zero of the level always on the eye-piece side)
7: chronometer time $\bar{T}$; the mean value of $N = 27$ contact times
8: chronometer correction: $(UTC - \bar{T})$ from radio time signals

A common adjustment of all the stars measured per station gives the following matrices of weight coefficients:

$$\text{Ubachsberg: } Q = \begin{pmatrix} 0.1678 & -0.0009 & 0.0000 \\ & 0.1655 & 0.0002 \\ & & 0.0278 \end{pmatrix}$$

$$\text{Tongeren: } Q = \begin{pmatrix} 0.1802 & -0.0019 & -0.0008 \\ & 0.1957 & -0.0000 \\ & & 0.0313 \end{pmatrix}$$

The final results, corrected for the polar motion and reduced to the centre, are shown in table 4.1. It shows a favourable standard deviation of the geodetic azimuth due to the negative correlation between the astronomical azimuth and the astronomical longitude.

Table 4.1

station	quantity		$\hat{\sigma}$
Ubachsberg	φ =	50°50′53″.432	0″.41
Centre 1890	λ = −	5°57′04″.320	0″.64
	A =	258°15′24″.273	0″.53
	Ag =	258°15′30″.558	0″.17
Tongeren	φ =	50°46′55″.775	0″.48
Station A	λ = −	5°27′48″.570	0″.78
	A =	77°52′43″.958	0″.64
	Ag =	77°52′47″.306	0″.20

5 Azimuth determinations (Goedereede, Zierikzee)

The astronomical azimuths Goedereede–Zierikzee and Zierikzee–Goedereede were determined by Polaris in 1969 and 1973 respectively. The measurements and the computations were carried out in the usual way, a brief description of which is given below.

The horizontal angle between the reference mark and Polaris was measured using a first order universal theodolite (Wild T4 or Kern DKM3A) in the following sequence:

face left: – reference mark: 2 × (pointing and reading the horizontal circle)
– Polaris: 2 × (pointing and reading the horizontal circle including the striding level)
face right: – Polaris: 2 ×
– reference mark: 2 ×

Such a group of four single series is called one set of observations. At each station about 24 sets should be measured, spread over several nights, in order to obtain an external accurancy of approximately 0″.2 for the mean azimuth.

For the time keeping an Omega chronograph was used, by which the time of pointing to Polaris was recorded by means of a tap-key. The star's hour angle is computed as follows:

$$\left.\begin{aligned} UTC &= T+(UTC-T) \\ UT1 &= UTC+(UT1-UTC) \\ GAST &= 1.0027379 \times UT1 + GAST(0^h UT) \\ t &= GAST-\alpha-\lambda \end{aligned}\right\} \qquad (5.1)$$

in which:

T = the time recorded by the chronograph
$(UTC-T)$ = chronometer correction determined by radio time signals of HBG (Switzerland)
$(UT1-UTC)$ = correction to the time signal according to Bureau International de l'Heure
t = local hour angle of the star.

The star's azimuth (counting clockwise from the north) is then computed from:

$$\tan a = \frac{\sin t}{\sin\varphi\cos t - \cos\varphi\tan\delta} \quad \ldots \quad (5.2)$$

The horizontal angle measured between the reference mark and Polaris was corrected in the following way:

$$\psi = \psi' - R(\psi') \mp p(M - M_0)\cot z + \Delta a_A \quad \ldots \quad (5.3)$$

in which:

ψ' = horizontal angle from the circle reading (Star-R.M.)
$R(\psi')$ = periodical horizontal circle error of the angle ψ', computed from the circle readings (φ) according to appendix IV and [7], appendix 1.
p = level value: Wild T4: $p = 1''.11$ per division of 2 mm (level No. 668)
DKM 3A: $p = 1''.24$ per division of 2 mm (level No. 152002)
(if zero of the level on the circle side: upper sign refes to face left, lower sign to face right)
M = $\frac{1}{2}(l+r)$ mean value of the level reading
M_0 = reference position of the bubble
Δa_A = $-0''.32\cos\varphi\,\mathrm{cosec}\,z\cos a$ (=daily aberration)

Finally the azimuth of the reference mark is computed from (5.2) and (5.3):

$$A_{ij} = a_{ij} - \psi_{ij} \qquad \left.\begin{array}{ll} i = 1,2,\ldots n & \text{(number of sets)} \\ j = 1,2 & \text{(series in face left)} \\ j = 3,4 & \text{(series in face right)} \end{array}\right\} \quad \ldots \quad (5.4)$$

The mean values of the azimuth obtained with instrument positions left and right are, respectively:

$$\bar{A}_L = \frac{[A_{i,1} + A_{i,2}]}{2n} \qquad \bar{A}_R = \frac{[A_{i,3} + A_{i,4}]}{2n} \quad \ldots \quad (5.5)$$

from which follows the mean azimuth per night:

$$\bar{A} = \tfrac{1}{2}(\bar{A}_L + \bar{A}_R) \quad \ldots \quad (5.6)$$

The corrections to the single azimuths were computed as follows:

$$\left.\begin{array}{ll} \varepsilon_{i,1} = \bar{A}_L - A_{i,1} & \varepsilon_{i,3} = \bar{A}_R - A_{i,3} \\ \varepsilon_{i,2} = \bar{A}_L - A_{i,2} & \varepsilon_{i,4} = \bar{A}_R - A_{i,4} \end{array}\right\} \quad \ldots \quad (5.7)$$

from which the estimate of the variance of the mean azimuth is:

$$\hat{\sigma}_{\bar{A}}^2 = \frac{[\varepsilon_{ij}^2]}{4n(4n-2)} \qquad \text{(method A)} \quad \ldots \quad (5.8)$$

Another method is preferred for the computation of the variance in case the observations are spread over several nights. In order to eliminate the systematic instrumental errors, first the mean values of face left and face right are computed from:

$$A_{i,13} = \tfrac{1}{2}(A_{i,1} + A_{i,3})$$

$$A_{i,24} = \tfrac{1}{2}(A_{i,2} + A_{i,4})$$

Table 5.1

Station: Goedereede (pillar 2) — instr.: Wild T4/1957
$\varphi = 51°49'09''.7$ $\lambda = -0^h15^m54^s.35$ — observer: Steur
reference mark: Zierikzee (lamp 1969)

date: 1969	number of sets	adjusted azimuth A	$\hat{\sigma}$ method A	correction polar motion ΔA	corrected azimuth $A+\Delta A$	$\hat{\sigma}$ method B
May 22	6	192°45'09''.145	0''.16	−0''.590	192°45'08''.555	
May 29	6	08''.944	0''.27	−0''.582	08''.362	
June 3	6	08''.318	0''.28	−0''.575	07''.743	
June 4	6	08''.341	0''.23	−0''.572	07''.769	
June 5	6	08''.434	0''.19	−0''.570	07''.864	
June 11	6	08''.255	0''.27	−0''.559	07''.696	
mean		192°45'08''.573	0''.10	−0''.575	192°45'07''.998	0''.10

bearing traverse δ	−02'06''.900	
meridian conv. γ	− 0''.118	
azimuth Goedereede Centre 1896 – Zierikzee Centre 1896	192°43'00''.980	0''.10

Table 5.2

Station: Zierikzee (perm. mark 12) — instr.: DKM 3A No. 134824
$\varphi = 51°39'04''.6$ $\lambda = -0^h15^m39^s.62$ — observer: Steur
reference mark: Goedereede (pillar 2)

date: 1973	number of sets	adjusted azimuth A	$\hat{\sigma}$ method A	correction polar motion ΔA	corrected azimuth $A+\Delta A$	$\hat{\sigma}$ method B
Aug. 21	6	12°39'47''.850	0''.31	−0''.542	12°39'47''.308	
Aug. 22	6	47''.110	0''.29	−0''.543	46''.567	
Aug. 23	9	46''.777	0''.26	−0''.544	46''.233	
Aug. 28	3	47''.531	0''.24	−0''.547	46''.984	
weighted mean		12°39'47''.223	0''.15	−0''.544	12°39'46''.679	0''.15

bearing traverse δ	+20''.694	
meridian conv. γ	− 0''.302	
azimuth Zierikzee Centre 1896 – Goedereede Centre 1896	12°40'07''.071	0''.15

The corrections to these azimuths are:

$$\varepsilon_{i,13} = \bar{A} - A_{i,13}$$
$$\varepsilon_{i,24} = \bar{A} - A_{i,24}$$

in which $\bar{A}$ now denotes the mean value of all observations. Hence the variance of the mean azimuth is:

$$\hat{\sigma}_{\bar{A}}^2 = \frac{[\varepsilon_{i,13}^2 + \varepsilon_{i,24}^2]}{2n(2n-1)} \qquad \text{(method B)}$$

The observations and some additional data are given in appendix III, in which:

column 1: set number
2: face: (1) = left; (2) = right
3: horizontal circle reading reference mark
4: horizontal circle reading star
5: mean value of the level reading (zero of the level always on the vertical circle side)
6: chronometer time: T

The results of the computation are shown in the tables 5.1 and 5.2. The standard deviation of the mean azimuth per night is computed using method A. Applying the Bartlett-test to these standard deviations indicates that the measurements of the various nights are homogeneous. However, some differences between the mean values have little significance. In addition the standard deviation of the station's mean value was computed applying method B; i.e. taking into account all observations with respect to the station's mean azimuth. Method A and B give the same result:

Goedereede: $\hat{\sigma}_{\bar{A}} = 0''.10$
Zierikzee: $\hat{\sigma}_{\bar{A}} = 0''.15$

The latter values can be considered as the external accuracy.

6 Misclosures of the Laplace stations

6.1 *Method of computation*

The misclosure of a Laplace point can be computed from:

$$w = A_g - A_g^* \qquad (6.1)$$

in which both A_g and A_g^* indicate geodetic azimuths; A_g determined from the geodetic network, and A_g^* from geodetic-astronomical observations.

To check the primary network of The Netherlands (adjusted without Laplace points) and at the same time gain an insight into the quality of the six Laplace points, the geodetic azimuth is derived in the following way:

$$A_g = \psi - \varepsilon + \gamma \quad \ldots \quad (6.2)$$

in which ψ is the grid bearing, ε is the reduction of the direction to the Bessel ellipsoid and γ is the meridian convergence. These quantities can be computed from the plane rectangular coordinates of the network according to [10] and [4].

The geodetic azimuth A_g^* in (6.1) follows from the Laplace equation:

$$A_g^* = A - (\lambda - \lambda_g) \sin \varphi + \{(\lambda - \lambda_g) \cos \varphi \cos A - (\varphi - \varphi_g) \sin A\} \tan H \quad \ldots \quad (6.3)$$

in which:

φ, φ_g = latitude (astronomic or geodetic)
λ, λ_g = longitude (in this formula: positive east of Greenwich!)
A = astronomic azimuth
H = elevation angle

Geodetic latitude and geodetic longitude, also contained in formula (6.3), can be computed from plane rectangular coordinates applying the formulae given in [10]. The geodetic longitudes obtained in this way refer to the Amersfoort meridian, while the astronomic longitude is usually determined with respect to the Greenwich meridian. In order to have the same reference meridian for the longitudes in (6.3) we can:

a. reduce the astronomic longitude to the Amersfoort meridian, or
b. reduce the geodetic longitude to the Greenwich meridian.

In both reductions the astronomic longitude of Amersfoort should be used, so that in (b) in fact a fictious geodetic longitude is obtained. Both methods give, of course, the same result.

Since the longitude of Amersfoort is not determined with high precision (see [3]), it will have a systematic influence on the misclosures. The systematic error, however, will be eliminated by taking the relative misclosure between two Laplace points.

6.2 *Misclosures*

The misclosures were computed according to the above formulae. The geodetic latitudes and longitudes of the Laplace points are given in table 6.1.

The geodetic azimuths A_g and A_g^* computed by formulae (6.2) and (6.3) are given in table 6.2. It should be noted that the last term in (6.3) has been omitted, because in a flat country like The Netherlands, the elevation angle is practically zero.

Table 6.1

station	φ_g	λ_g (Greenwich)
Leeuwarden	53°12′14″.750	5°47′24″.655
Ameland	53°27′30″.999	5°46′54″.367
Goedereede	51°49′09″.697	3°58′33″.549
Zierikzee	51°39′04″.346	3°54′53″.967
Ubachsberg	50°50′49″.180	5°57′12″.425
Tongeren	50°46′53″.616	5°27′52″.892

Table 6.2

station	A_g	σ_{A_g}	A_g^*	$\sigma_{A_g^*}$	$w = A_g - A_g^*$
Leeuwarden	358°31′56″.063	0″.42	358°31′58″.277	0″.36	−2″.214
Ameland	179°05′49″.063	0″.41	179°05′51″.168	0″.25	−2″.105
Goedereede	192°42′58″.386	0″.46	192°42′59″.867	0″.13	−1″.481
Zierikzee	12°40′05″.980	0″.46	12°40′07″.316	0″.17	−1″.336
Ubachsberg	258°15′26″.413	0″.48	258°15′30″.558	0″.17	−4″.145
Tongeren	77°52′42″.590	0″.48	77°52′47″.306	0″.20	−4″.716

From the misclosures w obtained in table 6.2 the following conclusions can be drawn:

- all the misclosures are negative, obviously effected by the approximate longitude of Amersfoort; ($\lambda = 5°23'15''.500$);
- assuming the condition $[w] = 0$, the following longitude of Amersfoort is obtained: $\lambda = 5°23'12''.114$;
- the relative misclosures between the different Laplace points are small;
- the largest relative misclosures, average 2″.6, are obtained between the twin Laplace point Ubachsberg–Tongeren and the other points.

6.3 *The precision of the geodetic part of the Laplace azimuth*

In table 6.2 the precisions of the geodetic azimuths A_g are also given. These data were computed in the following way.

Let us consider the geodetic part of the Laplace quantity:

$$L_i = A_{ik} + \lambda_i \sin \varphi_i \quad (6.4)$$

Expressing A_{ik} and λ_i in plane rectangular coordinates, (see(6.2)) and ignoring the quantities ε and γ we obtain:

$$L_i = \arctan \frac{x_k - x_i}{y_k - y_i} - 2.551 \times 10^{-7} x_i \sin \varphi_i \quad (6.5)$$

Linearisation of (6.5) gives:

$$\Delta L_i = \frac{\sin A_{ik}}{s_{ik}} \Delta y_i - \frac{\cos A_{ik}}{s_{ik}} \Delta x_i - \frac{\sin A_{ik}}{s_{ik}} \Delta y_k + \frac{\cos A_{ik}}{s_{ik}} \Delta x_k - 2.551 \times 10^{-7} \sin \varphi_i \Delta x_i \quad (6.6)$$

in which s_{ik} is the distance between the Laplace point i and the azimuth point k. Denoting the coefficients of the coordinates by a, b, c, d, we then have:

$$\Delta L_i = a_i \Delta y_i + b_i \Delta x_i + c_i \Delta y_k + d_i \Delta x_k \quad (6.7)$$

Based on equation (6.7) the matrix of weight coefficients of the six Laplace points were computed, using the covariance matrix of the coordinates related to the base Amersfoort–Veluwe (see appendix V). The computations were carried out by Mr. J. J. Kok of the Computing Centre of the Delft Geodetic Institute. The results of this computation, in (sec of arc)^2, are shown in table 6.3.

Table 6.3 The matrix of weight coefficients of the geodetic part of the Laplace quantity

	L	A	G	Z	U	T
Leeuwarden	+.1736	+.1726	+.0224	+.0225	+.0210	+.0210
Ameland	+.1726	+.1716	+.0223	+.0224	+.0208	+.0209
Goedereede	+.0224	+.0223	+.2100	+.2108	+.0552	+.0557
Zierikzee	+.0225	+.0224	+.2108	+.2116	+.0554	+.0558
Ubachsberg	+.0210	+.0208	+.0552	+.0554	+.2332	+.2336
Tongeren	+.0210	+.0209	+.0557	+.0558	+.2336	+.2340

Since the variance of the coordinates of the azimuth point Hallum are not available, the points Ameland and Leeuwarden were used as azimuth points instead of Hallum.

The standard deviations σ_{A_g} shown in table 6.2 are obtained from the matrix of variance of table 6.3, by taking the square root of the figures in the diagonal. Moreover, the data of tables 6.2 and 6.3 make it possible to compute the standard deviations of the misclosures and those of the relative misclosures. The results of these computations are given in table 6.4.

Table 6.4 Standard deviations of the misclosures and of the relative misclosures

station	L	A	G	Z	U	T
Leeuwarden	0″.55	0″.44	0″.70	0″.71	0″.72	0″.73
Ameland		0″.48	0″.65	0″.66	0″.67	0″.68
Goedereede			0″.48	0″.21	0″.62	0″.62
Zierikzee				0″.49	0″.63	0″.63
Ubachsberg					0″.51	0″.26
Tongeren						0″.52

From table 6.4, for example, the standard deviation of the misclosure of the Laplace point Leeuwarden is 0″.55, and the standard deviation of the relative misclosure between Leeuwarden–Ameland is 0″.44. The latter is favourably influenced by the strong correlation between the geodetic data (see table 6.3). It should be noted that the relative misclosures between Leeuwarden–Ameland–Goedereede–Zierikzee are quite in accordance with their theoretical standard deviations, while the relative misclosures of those stations with Ubachsberg and Tongeren are considerably larger.

Acknowledgements

The geodetic-astronomical observations were carried out by the Netherlands Triangulation Service. The organization of the fieldwork of the recent measurements of the Laplace stations Ubachsberg, Tongeren, Zierikzee and Goedereede has, since 1968, been the responsibility of Mr. M. Haarsma, who also assisted in many respects with the preparation of the present report. The author also expresses his gratitude to Prof. G. J. Bruins, in charge of the longitude determinations in 1947–1950, for the helpful information provided. The assistance of Mr. F. Reneman who wrote the computer programmes for the IBM 360/65 is gratefully acknowledged.

References

[1] Déterminations de la latitude et d'un azimut aux stations Oirschot, Utrecht, Sambeek, Wolberg, Harikerberg, Sleen, Schoorl, Zierikzee, Terschelling, Ameland, Leeuwarden, Urk et Groningen. Commission Géodésique Néerlandaise, Delft, 1904.

[2] Déterminations de la difference de longitude Leyde-Ubagsberg, de l'azimut de la direction Ubagsberg-Sittard et de la latitude d'Ubagsberg. Commission Géodésique Néerlandaise, Delft, 1905.

[3] Hk. J. Heuvelink – De stereografische kaartprojectie in hare toepassing bij de Rijksdriehoeksmeting. Netherlands Geodetic Commission, Delft, 1918.

[4] Hk. J. Heuvelink – Triangulation du Royaume des Pays-Bas, Tome second. Commission Geodésique Néerlandaise, Delft, 1921.

[5] G. J. Bruins – Astronomische lengtebepaling in Leeuwarden en op Ameland. Tijdschrift voor Kadaster en Landmeetkunde 1951, pp. 204–224.

[6] W. Bowie – Determination of time, longitude, latitude and azimuth. Special publication No. 14, U.S. Coast and Geodetic Survey.

[7] G. J. Husti – The twin Laplace point Ubachsberg-Tongeren applying the Black Method. Netherlands Geodetic Commission, Publications on Geodesy, New Series, Vol. 4, No. 1, Delft, 1971.

[8] Jordan, Eggert and Kneissl – Handbuch der Vermessungskunde. Band IIa. Geodätische Astronomie. J. B. Metzlersche Verlagsbuchhandlung, Stuttgart, 1970.

[9] R. Roelofs – Astronomy Applied to Land Surveying. Ahrend, Amsterdam, 1950.

[10] Handleiding voor de technische werkzaamheden van het Kadaster (Manual for the technical activities of the Castral Service in The Netherlands) The Hague, 1956.

[11] A. Hald – Statistical Theory with Engineering Applications. Chapman en Hall, London, 1951.

Appendix I

LONGITUDE BY MERIDIAN TRANSIT OF STARS.

STATION. . . . . : LEEUWARDEN.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : MAY 28 - 29, 1947.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(FYP)-T AT 20H 6M: $0^h\ 6^m\ 45^s.600$
CHRON. RATE DIT. . . . : $-0^s.055$/12H

APPROXIMATE VALUES:
LATITUDE . . . . : $53^\circ 12' 14''.75$
LONGITUDE. . . . . . . : $-0^h 23^m\ 9^s.64$

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
521	E	28.15	$21^h\ 10^m\ 50^s.024$	$0^s.010$	$64^\circ 37' 43''$	0.41	$0^h 29^m 54^s.710$
522		28.00	21 15 48.167	0.014	25 20 31	0.94	0 29 55.670
526		28.10	21 21 02.798	0.011	19 27 27	0.98	0 29 55.755
1379		27.75	21 35 29.610	0.007	75 55 54	0.16	0 29 53.506
550		27.30	21 58 38.842	0.011	74 22 20	0.19	0 29 53.796
554		27.30	22 04 28.926	0.007	66 08 35	0.37	0 29 54.534
1396	W	33.15	22 12 38.419	0.012	25 04 28	0.94	0 29 55.804
565		33.25	22 21 43.677	0.012	67 32 52	0.34	0 29 54.655
569		33.20	22 28 30.440	0.008	72 01 21	0.25	0 29 54.279
571		33.30	22 31 24.119	0.011	59 09 04	0.53	0 29 55.072
578		33.25	22 40 02.312	0.009	26 53 31	0.93	0 29 55.734
587		33.30	22 53 27.441	0.007	62 45 46	0.45	0 29 54.884
593	W	33.35	23 02 55.522	0.013	27 01 49	0.93	0 29 55.731
598		33.40	23 08 26.663	0.009	58 42 22	0.54	0 29 55.139
1421		33.35	23 13 10.924	0.011	17 11 12	0.98	0 29 55.869
606		33.70	23 19 54.661	0.008	76 00 42	0.16	0 29 54.009
612		33.55	23 26 36.663	0.007	75 52 41	0.16	0 29 53.974
619		33.70	23 35 35.187	0.007	68 52 58	0.31	0 29 54.746
1440	E	26.15	23 56 56.540	0.011	24 44 40	0.95	0 29 55.702
634		26.05	0 05 37.666	0.015	31 00 12	0.90	0 29 55.531
639		25.75	0 16 01.218	0.014	65 46 47	0.38	0 29 54.619
659		25.50	0 39 30.676	0.012	68 10 08	0.33	0 29 54.269
664		25.50	0 44 35.136	0.011	68 46 58	0.32	0 29 54.206
670		25.50	0 50 12.402	0.010	72 10 31	0.24	0 29 53.898

STATION. . . . . : LEEUWARDEN.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : MAY 29 - 30, 1947.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(FYP)-T AT 20H 6M: 0 6 47.416
CHRON. RATE DIT. . . . : -0.043/12H

APPROXIMATE VALUES:
LATITUDE . . . . : 53 12 14.75
LONGITUDE. . . . . . . : -0 23 9.64

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
521	E	29.85	21 06 51.998	0.012	64 37 43	0.41	0 29 56.357
522		29.70	21 11 50.220	0.011	25 20 31	0.94	0 29 57.510
526		29.50	21 17 04.907	0.014	19 27 27	0.98	0 29 57.590
1379		29.10	21 31 31.466	0.011	75 55 54	0.16	0 29 55.117
550		28.70	21 54 40.767	0.011	74 22 20	0.19	0 29 55.376
554		28.55	22 00 30.849	0.012	66 08 35	0.37	0 29 56.339
1396	W	33.45	22 08 40.688	0.012	25 04 28	0.94	0 29 57.655
565		33.50	22 17 45.921	0.010	67 32 52	0.34	0 29 56.561
569		33.55	22 24 32.751	0.010	72 01 21	0.25	0 29 56.164
571		33.55	22 27 26.342	0.009	59 09 04	0.53	0 29 56.988
578		33.50	22 36 04.514	0.013	26 53 31	0.93	0 29 57.650
587		33.60	22 49 29.645	0.009	62 45 46	0.45	0 29 56.837
593	W	33.55	22 58 57.802	0.015	27 01 49	0.93	0 29 57.566
598		33.60	23 04 28.952	0.011	58 42 22	0.54	0 29 56.983
1421		33.55	23 09 13.152	0.014	17 11 12	0.98	0 29 57.752
606		33.65	23 15 56.980	0.009	76 00 42	0.16	0 29 55.752
612		33.70	23 22 39.025	0.005	75 52 41	0.16	0 29 55.761
619		33.65	23 31 37.597	0.011	68 52 58	0.31	0 29 56.410
1440	E	27.80	23 52 58.565	0.010	24 44 40	0.95	0 29 57.592
634		27.80	0 01 39.625	0.011	31 00 12	0.90	0 29 57.455
639		27.40	0 12 03.162	0.009	65 46 47	0.38	0 29 56.329
659		27.30	0 35 32.532	0.006	68 10 08	0.33	0 29 55.984
664		27.10	0 40 36.955	0.008	68 46 58	0.32	0 29 56.009
670		27.10	0 46 14.234	0.006	72 10 31	0.24	0 29 55.614

LONGITUDE BY MERIDIAN TRANSIT OF STARS.

STATION. . . . . : LEEUWARDEN.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : MAY 30 - 31, 1947.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(FYP)-T AT 20H 6M: 0 6 47.317
CHRON. RATE DIT. . . . : -0.044/12H

APPROXIMATE VALUES:
LATITUDE . . . . : 53 12 14.75
LONGITUDE. . . . . . . : -0 23 9.64

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
521	E	30.85	21 02 54.282	0.008	64 37 43	0.41	0 29 57.878
522		30.70	21 07 53.678	0.011	25 20 31	0.94	0 29 58.024
526		30.60	21 13 08.351	0.014	19 27 27	0.98	0 29 58.122
1379		30.20	21 27 32.105	0.005	75 55 54	0.16	0 29 58.047
550		29.80	21 50 41.751	0.007	74 22 20	0.19	0 29 58.018
554		29.65	21 56 33.121	0.005	66 08 35	0.37	0 29 57.839
1396	W	31.65	-------------	----	25 04 28	0.94	0 29 -----
565		31.90	22 13 51.080	0.010	67 32 52	0.34	0 29 55.015
569		31.75	22 20 38.000	0.010	72 01 21	0.25	0 29 54.358
571		31.65	22 23 31.368	0.009	59 09 04	0.53	0 29 55.624
578		31.70	22 32 09.343	0.009	26 53 31	0.93	0 29 56.707
587		32.00	22 45 34.743	0.013	62 45 46	0.45	0 29 55.432
593	W	31.90	22 55 02.531	0.011	27 01 49	0.93	0 29 56.742
598		32.00	23 00 33.912	0.006	58 42 22	0.54	0 29 55.764
1421		32.00	23 05 17.969	0.012	17 11 12	0.98	0 29 56.882
606		32.30	23 12 02.616	0.007	76 00 42	0.16	0 29 53.611
612		32.25	23 18 44.692	0.007	75 52 41	0.16	0 29 53.552
619		32.25	23 27 42.776	0.007	68 52 58	0.31	0 29 54.895
1440	E	28.85	23 49 02.206	0.010	24 44 40	0.95	0 29 57.934
634		28.70	23 57 43.126	0.014	31 00 12	0.90	0 29 57.943
639		28.45	0 08 05.455	0.010	65 46 47	0.38	0 29 57.855
659		28.20	0 31 34.647	0.008	68 10 08	0.33	0 29 57.714
664		28.30	0 36 39.014	0.007	68 46 58	0.32	0 29 57.695
670		28.15	0 42 15.732	0.008	72 10 31	0.24	0 29 57.861

STATION. . . . . : LEEUWARDEN.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : MAY 31 - JUNE 1, 1947.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(FYP)-T AT 20H 6M: 0 6 47.219
CHRON. RATE DIT. . . . : -0.053/12H

APPROXIMATE VALUES:
LATITUDE . . . . : 53 12 14.75
LONGITUDE. . . . . . . : -0 23 9.64

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
521	E	30.30	20 58 58.465	0.009	64 37 43	0.41	0 29 57.878
522		30.15	21 03 57.948	0.010	25 20 31	0.94	0 29 57.901
526		30.10	21 09 12.619	0.015	19 27 27	0.98	0 29 57.988
1379		29.55	21 23 36.339	0.006	75 55 54	0.16	0 29 58.132
550		28.85	21 46 46.012	0.027	74 22 20	0.19	0 29 58.181
554		28.80	21 52 37.322	0.005	66 08 35	0.37	0 29 57.942
1396	W	31.55	22 00 49.758	0.012	25 04 28	0.94	0 29 56.552
565		31.70	22 09 55.421	0.009	67 32 52	0.34	0 29 54.687
569		31.85	22 16 42.558	0.009	72 01 21	0.25	0 29 53.897
571		31.80	22 19 35.696	0.007	59 09 04	0.53	0 29 55.409
578		31.80	22 28 13.586	0.009	26 53 31	0.93	0 29 56.567
587		32.15	22 41 39.155	0.007	62 45 46	0.45	0 29 55.141
593	W	32.10	22 51 06.941	0.016	27 01 49	0.93	0 29 56.448
598		32.20	22 56 38.286	0.010	58 42 22	0.54	0 29 55.521
1421		32.15	23 01 22.312	0.011	17 11 12	0.98	0 29 56.651
606		32.35	23 08 07.385	0.008	76 00 42	0.16	0 29 52.940
612		32.35	23 14 49.309	0.008	75 52 41	0.16	0 29 53.060
619		32.50	23 23 47.373	0.008	68 52 58	0.31	0 29 54.467
1440	E	27.45	23 45 06.409	0.011	24 44 40	0.95	0 29 57.988
634		27.20	23 53 47.385	0.010	31 00 12	0.90	0 29 57.971
639		26.90	0 04 09.811	0.009	65 46 47	0.38	0 29 58.023
659		26.85	0 27 38.939	0.010	68 10 08	0.33	0 29 57.930
664		26.80	0 32 43.312	0.010	68 46 58	0.32	0 29 57.967
670		26.75	0 38 20.189	0.008	72 10 31	0.24	0 29 58.011

LONGITUDE BY MERIDIAN TRANSIT OF STARS.

STATION. . . . . : AMELAND.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : JUNE 16 - 17, 1947.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(FYP)-T AT 20H 6M: 0 9 17.076
CHRON. RATE DIT. . . . : -0.041/12H

APPROXIMATE VALUES:
LATITUDE . . . . : 53 27 30.999
LONGITUDE. . . . . . . : -0 23 7.624

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
1396	E	28.35	20 55 28.008	0.011	25 04 28	0.94	0 32 23.677
565		28.15	21 04 26.464	0.008	67 32 58	0.34	0 32 28.714
569		28.05	21 11 10.962	0.008	72 01 28	0.25	0 32 30.446
571		27.90	21 14 09.598	0.009	59 09 09	0.53	0 32 26.767
578		28.00	21 22 51.818	0.009	26 53 31	0.93	0 32 23.751
587		27.65	21 36 12.093	0.008	62 45 50	0.45	0 32 27.461
593	W	30.30	21 45 46.236	0.013	27 01 48	0.93	0 32 22.372
598		30.25	21 51 14.313	0.012	58 42 25	0.54	0 32 24.352
1421		30.00	------------	----	17 11 09	0.98	0 32 -----
606		30.05	22 02 36.041	0.013	76 00 45	0.16	0 32 28.277
612		29.95	22 09 18.041	0.011	75 52 44	0.16	0 32 28.324
619		29.95	22 18 20.204	0.012	68 53 00	0.31	0 32 26.104
1440	W	29.35	22 39 47.178	0.016	24 44 37	0.95	0 32 22.379
634		29.20	22 48 27.751	0.011	31 00 09	0.90	0 32 22.677
639		29.35	22 58 46.782	0.008	65 46 46	0.38	0 32 25.456
1454		29.20	23 08 07.955	0.015	18 06 33	0.98	0 32 22.167
659		29.25	23 22 15.341	0.010	68 10 05	0.33	0 32 25.865
664		29.15	23 27 19.507	0.010	68 46 54	0.32	0 32 26.056
670		29.20	23 32 55.428	0.007	72 10 28	0.24	0 32 26.870
675	E	28.65	23 41 45.981	0.010	76 58 12	0.14	0 32 33.558
674		28.65	23 45 43.971	0.011	29 15 4	0.92	0 32 23.912
681		28.35	23 55 28.623	0.014	28 45 9	0.92	0 32 23.855
685		28.05	0 03 31.824	0.011	64 22 39	0.41	0 32 27.912
695		27.90	0 11 54.041	0.010	72 42 31	0.23	0 32 31.071
700		27.80	0 22 9.075	0.011	77 30 19	0.13	0 32 34.315

STATION. . . . . : AMELAND.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : JUNE 17 - 18, 1947.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(FYP)-T AT 20H 6M: 0 53 7.682
CHRON. RATE DIT. . . . : -0.048/12H

APPROXIMATE VALUES:
LATITUDE . . . . : 53 27 30.999
LONGITUDE. . . . . . . : -0 23 7.624

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
1396	E	29.35	20 07 41.382	0.008	25 04 28	0.94	1 16 14.274
565		28.95	20 16 39.586	0.007	67 32 58	0.34	1 16 19.410
569		28.85	20 23 24.007	0.008	72 01 28	0.25	1 16 21.162
571		28.95	20 26 22.825	0.007	59 09 09	0.53	1 16 17.376
578		29.05	20 35 05.197	0.008	26 53 31	0.93	1 16 14.336
587		28.65	20 48 25.193	0.008	62 45 50	0.45	1 16 18.179
593	W	28.90	20 57 59.593	0.012	27 01 48	0.93	1 16 12.942
598		28.95	21 03 27.587	0.013	58 42 25	0.54	1 16 14.865
1421*		28.70	21 08 15.603	0.010	17 11 09	0.98	1 16 12.578
606		28.90	21 14 49.240	0.010	76 00 45	0.16	1 16 18.615
612		28.75	21 21 31.239	0.012	75 52 44	0.16	1 16 18.654
619		28.70	21 30 33.684	0.007	68 53 00	0.31	1 16 16.306
1440	W	28.40	21 52 00.688	0.009	24 44 37	0.95	1 16 12.857
634		28.55	22 00 41.288	0.011	31 00 09	0.90	1 16 13.151
639		28.65	22 11 00.195	0.011	65 46 46	0.38	1 16 15.928
1454		28.25	22 20 21.515	0.008	18 06 33	0.98	1 16 12.608
659		28.60	22 34 28.796	0.007	68 10 05	0.33	1 16 16.299
664		28.75	22 39 32.972	0.007	68 46 54	0.32	1 16 16.552
670		28.80	22 45 08.807	0.012	72 10 28	0.24	1 16 17.429
675	E	28.85	22 53 58.956	0.008	76 58 12	0.14	1 16 24.557
674		28.90	22 57 57.472	0.014	29 15 04	0.92	1 16 14.480
681		28.55	23 07 42.115	0.016	28 45 09	0.92	1 16 14.439
685		28.30	23 15 45.254	0.010	64 22 39	0.41	1 16 18.511
695		28.05	23 24 07.426	0.009	72 42 31	0.23	1 16 21.723
700		27.90	23 34 22.289	0.009	77 30 19	0.13	1 16 25.145

* no.1421 is not used in the computation

LONGITUDE BY MERIDIAN TRANSIT OF STARS.

STATION. . . . . : AMELAND.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : JUNE 18 - 19, 1947.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(FYP)-T AT 20H 6M: 0 1 55.994
CHRON. RATE DIT. . . . : -0.050/12H

APPROXIMATE VALUES:
LATITUDE . . . . : 53 27 30.999
LONGITUDE. . . . . . . : -0 23 7.624

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
1396	E	30.55	20 54 55.102	0.014	25 04 28	0.94	0 25 04.499
565		30.20	21 03 57.359	0.010	67 32 58	0.34	0 25 05.321
569		30.10	21 10 43.088	0.007	72 01 28	0.25	0 25 05.681
571		30.00	21 13 38.921	0.010	59 09 09	0.53	0 25 05.110
578		29.95	21 22 19.069	0.008	26 53 31	0.93	0 25 04.443
587		29.65	21 35 42.021	0.010	62 45 50	0.45	0 25 05.167
593	W	29.45	21 45 13.582	0.011	27 01 48	0.93	0 25 03.098
598		29.45	21 50 44.036	0.010	58 42 25	0.54	0 25 02.594
1421		29.30	21 55 29.154	0.013	17 11 09	0.98	0 25 03.172
606		----	------------	----	76 00 45	0.16	0 25 ------
612		29.35	22 08 52.695	0.009	75 52 44	0.16	0 25 01.491
619		29.05	22 17 52.110	0.010	68 53 00	0.31	0 25 02.046
1440	W	28.95	22 39 14.653	0.010	24 44 37	0.95	0 25 03.041
634		28.95	22 47 55.565	0.011	31 00 09	0.90	0 25 03.012
639		29.10	22 58 18.010	0.010	65 46 46	0.38	0 25 02.308
1454		29.00	23 07 35.159	0.014	18 06 33	0.98	0 25 03.132
659		29.05	23 20 47.189	0.010	68 10 05	0.33	0 25 02.118
664		29.05	23 26 51.634	0.010	68 46 54	0.32	0 25 02.054
670		29.05	23 32 28.534	0.007	72 10 28	0.24	0 25 01.865
675	E	29.75	23 41 20.711	0.007	76 58 12	0.14	0 25 06.438
674		29.85	23 45 11.393	0.010	29 15 04	0.92	0 25 04.542
681		29.70	23 54 55.956	0.009	28 45 09	0.92	0 25 04.559
685		29.30	0 03 02.244	0.010	64 22 39	0.41	0 25 05.352
695		29.25	0 11 26.707	0.007	72 42 31	0.23	0 25 06.093
700		29.05	0 21 44.030	0.006	77 30 19	0.13	0 25 06.932

STATION. . . . . : AMELAND.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : JUNE 24 - 25, 1947.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(FYP)-T AT 20H 6M: 0 2 3.811
CHRON. RATE DIT. . . . : -0.043/12H

APPROXIMATE VALUES:
LATITUDE . . . . : 53 27 30.999
LONGITUDE. . . . . . . : -0 23 7.624

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
1396	E	29.60	20 31 12.360	0.011	25 04 28	0.94	0 25 11.841
565		29.25	20 40 15.206	0.012	67 32 58	0.34	0 25 12.092
569		29.25	20 47 00.991	0.010	72 01 28	0.25	0 25 12.358
571		29.30	20 49 56.560	0.011	59 09 09	0.53	0 25 12.036
578		29.30	20 58 36.288	0.011	26 53 31	0.93	0 25 11.799
587		29.00	21 11 59.745	0.008	62 45 50	0.45	0 25 12.006
593	W	36.10	21 21 30.593	0.012	27 01 48	0.93	0 25 11.192
598		36.10	21 27 01.182	0.008	58 42 25	0.54	0 25 11.336
1421*		35.95	21 31 46.146	0.012	17 11 09	0.98	0 25 11.441
606		36.05	21 38 28.149	0.006	76 00 45	0.16	0 25 11.119
612		36.05	21 45 10.258	0.007	75 52 44	0.16	0 25 11.100
619		36.00	21 54 09.408	0.008	68 53 00	0.31	0 25 11.258
1440	W	35.60	22 15 31.660	0.014	24 44 37	0.95	0 25 11.304
634		35.50	22 24 12.677	0.015	31 00 09	0.90	0 25 11.239
639		35.60	22 34 35.418	0.009	65 46 46	0.38	0 25 11.118
1454		35.50	22 43 52.208	0.012	18 06 33	0.98	0 25 11.277
659		35.65	22 58 04.773	0.009	68 10 05	0.33	0 25 10.960
664		35.65	23 03 09.023	0.013	68 46 54	0.32	0 25 11.137
670		35.65	23 08 46.062	0.011	72 10 28	0.24	0 25 11.118
675	E	29.30	23 17 38.984	0.008	76 58 12	0.14	0 25 12.872
674		29.40	23 21 28.639	0.009	29 15 04	0.92	0 25 11.917
681		29.20	23 31 13.206	0.013	28 45 09	0.92	0 25 11.943
685		28.95	23 39 19.943	0.008	64 22 39	0.41	0 25 12.279
695		28.80	23 47 44.859	0.006	72 42 31	0.23	0 25 12.615
700		28.70	23 58 02.680	0.006	77 30 19	0.13	0 25 13.051

* no.1421 is not used in the computation

LONGITUDE BY MERIDIAN TRANSIT OF STARS.

STATION. . . . . : AMELAND.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : JUNE 25 - 26, 1947.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(FYP)-T AT 20H 6M: 0 2 3.750
CHRON. RATE DIT. . . . : -0.048/12H

APPROXIMATE VALUES:
LATITUDE . . . . : 53 27 30.999
LONGITUDE. . . . . . . : -0 23 7.624

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
1396	E	29.70	20 27 16.689	0.012	25 04 28	0.94	0 25 11.581
565		29.45	20 36 17.594	0.010	67 32 58	0.34	0 25 13.705
569		29.35	20 43 02.801	0.008	72 01 28	0.25	0 25 14.560
571		29.35	20 45 55.728	0.010	59 09 09	0.53	0 25 12.927
578		29.35	20 54 40.550	0.010	26 53 31	0.93	0 25 11.614
587		29.25	21 08 02.592	0.005	62 45 50	0.45	0 25 13.166
593	W	30.35	21 17 35.006	0.014	27 01 48	0.93	0 25 10.171
598		30.45	21 23 04.608	0.011	58 42 25	0.54	0 25 10.751
1421		30.25	21 27 50.768	0.012	17 11 09	0.98	0 25 10.259
606		30.35	21 34 29.550	0.008	76 00 45	0.16	0 25 11.283
612		30.30	21 41 11.617	0.006	75 52 44	0.16	0 25 11.307
619		30.05	21 50 11.548	0.006	68 53 00	0.31	0 25 10.972
1440	W	29.85	22 11 36.039	0.011	24 44 37	0.95	0 25 10.384
634		29.75	22 20 16.845	0.009	31 00 09	0.90	0 25 10.456
639		29.80	22 30 37.993	0.010	65 46 46	0.38	0 25 11.049
1454		29.75	22 39 56.782	0.010	18 06 33	0.98	0 25 10.233
659		29.70	22 54 07.012	0.011	68 10 05	0.33	0 25 11.042
664		29.75	22 59 11.488	0.010	68 46 54	0.32	0 25 10.966
670		29.80	23 04 48.092	0.010	72 10 28	0.24	0 25 11.107
675	E	29.65	23 13 35.748	0.006	76 58 12	0.14	0 25 16.032
674		29.65	23 17 33.018	0.010	29 15 04	0.92	0 25 11.606
681		29.40	23 27 17.556	0.009	28 45 09	0.92	0 25 11.667
685		29.05	23 35 22.879	0.006	64 22 39	0.41	0 25 13.410
695		28.75	23 43 46.817	0.006	72 42 31	0.23	0 25 14.769
700		28.65	23 54 03.422	0.006	77 30 19	0.13	0 25 16.331

STATION. . . . . : ZIERIKZEE.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : SEP 12 - 13,1949 (I).
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H 0 M: 4 15 24.831
CHRON. RATE DIT. . . . : -0.088/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 39 4.346
LONGITUDE. . . . . . . : -0 15 39.598

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
759	E	29.65	16 13 29.371	0.008	77 33 48	0.13	4 31 8.371
760		29.40	16 17 31.438	0.013	24 30 59	0.95	4 31 4.216
765		29.55	16 23 17.652	0.011	40 5 49	0.82	4 31 4.612
767		29.40	16 31 34.796	0.009	62 49 38	0.45	4 31 5.689
770		29.25	16 35 0.509	0.010	74 47 6	0.18	4 31 7.595
1539		29.25	16 39 6.596	0.010	21 1 29	0.97	4 31 4.133
777		29.35	16 41 32.142	0.012	45 6 7	0.76	4 31 4.678
783		29.25	16 44 3.955	0.009	61 38 44	0.47	4 31 5.656
786	W	30.20	16 55 13.074	0.016	27 52 2	0.93	4 31 3.562
1549		30.10	16 58 48.941	0.013	22 7 55	0.96	4 31 3.571
795		29.85	17 9 19.662	0.008	77 55 30	0.14	4 31 4.742
797		30.00	17 13 32.757	0.012	30 1 17	0.91	4 31 3.673
803		30.40	17 20 6.892	0.012	62 22 27	0.46	4 31 4.126
804		30.40	17 22 29.299	0.010	19 35 23	0.98	4 31 3.543
809		30.80	17 30 43.737	0.008	70 20 31	0.28	4 31 4.341
1570		30.15	17 38 5.295	0.009	19 5 34	0.98	4 31 3.625
817	W	30.95	17 43 51.987	0.010	71 4 54	0.27	4 31 4.325
1572		30.60	17 46 39.480	0.012	60 53 25	0.49	4 31 4.118
1575		31.00	17 50 15.959	0.016	29 56 27	0.91	4 31 3.784
1578		31.10	17 54 50.825	0.013	73 27 58	0.21	4 31 4.649
826		30.95	18 1 15.659	0.011	12 52 46	0.99	4 31 3.548
830		30.75	18 6 5.174	0.009	62 32 30	0.45	4 31 4.133
837		30.75	18 11 26.625	0.011	72 5 42	0.25	4 31 4.523
843		31.00	18 21 36.602	0.015	11 57 9	1.00	4 31 3.496
847	E	30.25	18 29 49.458	0.012	58 9 33	0.55	4 31 5.243
1594		30.35	18 33 54.369	0.007	75 58 7	0.16	4 31 7.063
853		30.30	18 39 21.614	0.010	63 19 28	0.44	4 31 5.495
857		30.30	18 43 8.086	0.014	29 57 34	0.91	4 31 4.596
859		30.90	18 46 35.545	0.015	23 18 7	0.96	4 31 4.506
863		30.75	18 50 21.137	0.009	65 56 14	0.38	4 31 5.787
1600		30.65	18 55 9.680	0.010	36 48 36	0.85	4 31 4.673
870		30.55	19 3 46.244	0.015	27 48 41	0.93	4 31 4.553

LONGITUDE BY MERIDIAN TRANSIT OF STARS.

STATION. . . . . : ZIERIKZEE.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : SEP 19 - 20,1949 (I)
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H 0 M: 4 10 30.052
CHRON. RATE DIT. . . . : -0.091/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 39 4.346
LONGITUDE. . . . . . . : -0 15 39.598

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
759	E	29.85	15 50 52.179	0.007	77 33 48	0.13	4 26 13.627
760		29.65	15 54 54.799	0.012	24 30 59	0.95	4 26 9.422
765		29.65	16 0 41.044	0.012	40 5 49	0.82	4 26 9.738
767		29.65	16 8 58.075	0.012	62 49 38	0.45	4 26 10.849
770		29.85	16 12 23.768	0.009	74 47 6	0.18	4 26 12.715
1539		29.75	16 16 29.981	0.011	21 1 29	0.97	4 26 9.358
777		29.70	16 19 55.472	0.008	45 6 7	0.76	4 26 9.908
783		29.70	16 24 27.414	0.009	61 38 44	0.47	4 26 10.749
786	W	29.60	16 32 36.490	0.015	27 52 2	0.93	4 26 8.774
1549		29.50	16 36 12.366	0.017	22 7 55	0.96	4 26 8.776
795		29.50	16 46 41.834	0.014	77 55 30	0.14	4 26 10.843
797		29.70	16 50 56.167	0.011	30 1 17	0.91	4 26 8.862
803		29.60	16 57 30.121	0.010	62 22 27	0.46	4 26 9.539
804		29.90	16 59 52.768	0.017	19 35 23	0.98	4 26 8.708
809		29.60	17 8 6.738	0.012	70 20 31	0.28	4 26 10.097
1570		30.15	17 15 28.844	0.016	19 5 34	0.98	4 26 8.670
817	W	30.15	17 21 14.344	0.025	71 4 54	0.27	4 26 10.621
1572		30.30	17 24 2.701	0.010	60 53 25	0.49	4 26 9.454
1575		30.35	17 27 39.545	0.013	29 56 27	0.91	4 26 8.868
1578		30.50	17 32 14.034	0.009	73 27 58	0.21	4 26 10.029
826		30.50	17 38 39.206	0.015	12 52 46	0.99	4 26 8.658
830		30.40	17 43 28.362	0.008	62 32 30	0.45	4 26 9.545
837		30.45	17 48 49.635	0.006	72 5 42	0.25	4 26 10.051
843		30.50	17 59 0.110	0.013	11 57 9	1.00	4 26 8.664
847	E	28.40	18 7 12.509	0.008	58 9 33	0.55	4 26 10.364
1594		28.60	18 11 16.225	0.013	75 58 7	0.16	4 26 12.887
853		28.55	18 16 44.454	0.008	63 19 28	0.44	4 26 10.785
857		28.65	18 20 31.580	0.016	29 57 34	0.91	4 26 9.537
859		28.85	18 23 59.116	0.014	23 18 7	0.96	4 26 9.352
863		28.80	18 27 43.968	0.008	65 56 14	0.38	4 26 10.996
1600		28.90	18 32 33.074	0.013	36 48 36	0.85	4 26 9.677
870		28.90	18 41 9.798	0.010	27 48 41	0.93	4 26 9.461

STATION. . . . . : ZIERIKZEE.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : SEP 19 - 20, 1949 (II).
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H 0M: 4 10 30.052
CHRON. RATE DIT. . . . : -0.091/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 39 4.346
LONGITUDE. . . . . . . : -0 15 39.598

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
875	E	29.45	18 50 38.774	0.012	56 53 31	0.57	4 26 10.325
880		29.25	18 57 55.788	0.011	23 28 0	0.96	4 26 9.484
882		29.35	19 2 21.148	0.009	61 60 28	0.47	4 26 10.675
885		29.40	19 6 22.547	0.010	12 29 5	1.00	4 26 9.298
1616		29.35	19 11 54.123	0.012	39 57 38	0.82	4 26 9.762
893		29.40	19 16 58.029	0.010	77 21 9	0.14	4 26 12.978
895		29.30	19 25 11.189	0.008	67 31 42	0.34	4 26 10.973
899		29.30	19 31 32.572	0.011	57 13 15	0.57	4 26 10.283
1629	W	29.15	19 34 53.400	0.016	24 51 49	0.95	4 26 8.816
2		29.30	19 46 8.695	0.013	58 52 25	0.53	4 26 9.345
7		29.45	19 50 17.991	0.013	14 54 22	0.99	4 26 8.751
1005		29.45	19 55 19.923	0.009	36 30 30	0.85	4 26 8.985
1009		29.50	19 58 5.624	0.017	37 41 30	0.84	4 26 9.140
1012		29.80	20 5 12.632	0.009	16 10 9	0.99	4 26 8.741
16		29.70	20 9 43.182	0.008	62 39 19	0.45	4 26 9.517
21		29.80	20 17 12.900	0.008	56 15 46	0.58	4 26 9.310
24	W	29.85	20 21 51.295	0.009	74 42 49	0.19	4 26 10.175
1020		30.15	20 25 53.305	0.014	16 40 18	0.99	4 26 8.803
32		30.15	20 33 11.089	0.012	60 26 44	0.50	4 26 9.432
1028		30.45	20 41 56.639	0.015	14 40 42	0.99	4 26 8.725
1032		30.45	20 48 14.348	0.012	20 46 11	0.97	4 26 8.823
45		30.45	20 56 9.947	0.013	26 60 8	0.93	4 26 8.921
46		30.40	21 1 47.895	0.008	67 52 6	0.34	4 26 9.761
1042		30.35	21 6 53.122	0.010	70 0 24	0.29	4 26 9.887
51	E	27.80	21 13 49.738	0.009	72 47 3	0.23	4 26 11.599
55		28.15	21 17 57.659	0.011	67 47 22	0.34	4 26 10.941
1050		28.30	21 24 49.980	0.015	16 42 30	0.99	4 26 9.244
63		28.40	21 30 5.827	0.010	63 25 24	0.43	4 26 10.691
70		28.55	21 38 24.294	0.008	72 10 43	0.24	4 26 11.660
74		28.55	21 43 39.654	0.014	23 13 40	0.96	4 26 9.395
1056		28.60	21 47 9.251	0.011	19 15 59	0.98	4 26 9.307
1059		28.60	21 52 9.497	0.015	24 48 47	0.95	4 26 9.373

LONGITUDE BY MERIDIAN TRANSIT OF STARS.

STATION. . . . . : ZIERIKZEE.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : SEP 20 - 21, 1949 (I).
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H 0 M: 4 10 29.909
CHRON. RATE DIT. . . . : -0.091/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 39 4.346
LONGITUDE. . . . . . . : -0 15 39.598

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
759	E	29.10	15 46 56.044	0.007	77 33 48	0.13	4 26 13.398
760		29.05	15 50 59.012	0.012	24 30 59	0.95	4 26 9.218
765		28.95	15 56 45.155	0.013	40 5 49	0.82	4 26 9.598
767		29.00	16 5 2.191	0.008	62 49 38	0.45	4 26 10.626
770		29.20	16 8 27.938	0.008	74 47 6	0.18	4 26 12.294
1539		29.15	16 12 34.217	0.008	21 1 29	0.97	4 26 9.138
777		29.20	16 15 59.651	0.012	45 6 7	0.76	4 26 9.721
783		29.25	16 20 31.524	0.008	61 38 44	0.47	4 26 10.588
786	W	29.35	16 28 40.667	0.011	27 52 2	0.93	4 26 8.704
1549		29.45	16 32 16.602	0.013	22 7 55	0.96	4 26 8.626
795		29.55	16 42 45.726	0.009	77 55 30	0.14	4 26 10.934
797		29.90	16 47 0.419	0.012	30 1 17	0.91	4 26 8.666
803		29.90	16 53 34.213	0.013	62 22 27	0.46	4 26 9.433
804		29.90	16 55 56.985	0.017	19 35 23	0.98	4 26 8.576
809		30.10	17 4 10.788	0.008	70 20 31	0.28	4 26 9.932
1570		30.35	17 11 32.991	0.011	19 5 34	0.98	4 26 8.586
817	W	30.15	17 17 19.015	0.009	71 4 54	0.27	4 26 10.000
1572		30.70	17 20 6.815	0.012	60 53 25	0.49	4 26 9.315
1575		30.40	17 23 43.794	0.013	29 56 27	0.91	4 26 8.695
1578		30.45	17 28 17.931	0.012	73 27 58	0.21	4 26 10.197
826		30.60	17 34 43.436	0.011	12 52 46	0.99	4 26 8.506
830		30.60	17 39 32.472	0.010	62 32 30	0.45	4 26 9.457
837		30.70	17 44 53.641	0.007	72 5 42	0.25	4 26 10.008
843		30.70	17 55 4.326	0.015	11 57 9	1.00	4 26 8.518
847	E	30.10	18 3 17.215	0.009	58 9 33	0.55	4 26 10.101
1594		30.35	18 7 21.864	0.009	75 58 7	0.16	4 26 12.050
853		30.25	18 12 49.349	0.010	63 19 28	0.44	4 26 10.387
857		30.35	18 16 35.912	0.009	29 57 34	0.91	4 26 9.502
859		30.45	18 20 3.335	0.009	23 18 7	0.96	4 26 9.399
863		30.65	18 23 48.831	0.009	65 56 14	0.38	4 26 10.710
1600		30.75	18 28 37.519	0.009	36 48 36	0.85	4 26 9.576
870		30.80	18 37 14.057	0.019	27 48 41	0.93	4 26 9.517

STATION. . . . . : ZIERIKZEE.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : SEP 20 - 21, 1949 (II).
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H 0 M: 4 10 29.909
CHRON. RATE DIT. . . . : -0.091/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 39 4.346
LONGITUDE. . . . . . . : -0 15 39.598

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
875	E	29.25	18 46 42.994	0.009	56 53 31	0.57	4 26 10.148
880		29.25	18 54 0.297	0.016	23 28 0	0.96	4 26 9.069
882		29.45	18 58 25.365	0.009	61 60 28	0.47	4 26 10.567
885		29.45	19 2 27.062	0.013	12 29 5	1.00	4 26 8.883
1616		29.45	19 7 58.469	0.009	39 57 38	0.82	4 26 9.523
893		29.50	19 13 1.884	0.008	77 21 9	0.14	4 26 13.247
895		29.50	19 21 15.261	0.008	67 31 42	0.34	4 26 11.049
899		29.45	19 27 36.808	0.010	57 13 15	0.57	4 26 10.173
1629	W	28.90	19 30 57.760	0.018	24 51 49	0.95	4 26 8.581
2		29.20	19 42 12.731	0.014	58 52 25	0.53	4 26 9.427
7		29.40	19 46 22.419	0.010	14 54 22	0.99	4 26 8.427
1005		29.55	19 51 24.205	0.013	36 30 30	0.85	4 26 8.787
1009		29.50	19 54 10.038	0.008	37 41 30	0.84	4 26 8.827
1012		29.70	20 1 17.003	0.013	16 10 9	0.99	4 26 8.481
16		29.70	20 5 47.246	0.014	62 39 19	0.45	4 26 9.556
21		29.85	20 13 17.059	0.011	56 15 46	0.58	4 26 9.243
24	W	29.85	20 17 54.997	0.007	74 42 49	0.19	4 26 10.580
1020		29.95	20 21 57.652	0.019	16 40 18	0.99	4 26 8.579
32		29.95	20 29 15.185	0.009	60 26 44	0.50	4 26 9.488
1028		30.05	20 38 1.041	0.012	14 40 42	0.99	4 26 8.465
1032		30.20	20 44 18.728	0.017	20 46 11	0.97	4 26 8.573
45		30.40	20 52 14.359	0.011	26 60 8	0.93	4 26 8.622
46		30.20	20 57 51.865	0.008	67 52 6	0.34	4 26 9.967
1042		30.45	21 2 57.026	0.008	70 0 24	0.29	4 26 10.072
51	E	27.70	21 9 53.591	0.010	72 47 3	0.23	4 26 11.837
55		27.75	21 14 1.502	0.009	67 47 22	0.34	4 26 11.103
1050		28.00	21 20 54.388	0.011	16 42 30	0.99	4 26 8.917
63		28.05	21 26 9.835	0.015	63 25 24	0.43	4 26 10.714
70		28.15	21 34 28.256	0.008	72 10 43	0.24	4 26 11.688
74		28.20	21 39 44.078	0.017	23 13 40	0.96	4 26 9.045
1056		28.20	21 43 13.625	0.009	19 15 59	0.98	4 26 9.005
1059		28.30	21 48 13.829	0.013	24 48 47	0.95	4 26 9.121

LONGITUDE BY MERIDIAN TRANSIT OF STARS.

STATION. . . . . : ZIERIKZEE.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : OKT 4 - 5, 1949 (I).
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H 0 M: 17 5 48.298
CHRON. RATE DIT. . . . : -0.090/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 39 4.346
LONGITUDE. . . . . . . : -0 15 39.598

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
759	E	30.50	1 56 35.867	0.008	77 33 48	0.13	17 21 30.141
760		30.30	2 0 37.738	0.011	24 30 59	0.95	17 21 27.685
765		30.25	2 6 23.975	0.012	40 5 49	0.82	17 21 27.954
767		30.50	2 14 41.271	0.009	62 49 38	0.45	17 21 28.635
770		30.50	2 18 7.355	0.008	74 47 6	0.18	17 21 29.634
1539		30.40	2 22 12.902	0.010	21 1 29	0.97	17 21 27.666
777		30.50	2 25 38.547	0.009	45 6 7	0.76	17 21 28.006
783		30.70	2 30 10.626	0.010	61 38 44	0.47	17 21 28.608
786	W	28.90	2 38 19.192	0.011	27 52 2	0.93	17 21 27.309
1549		29.00	2 41 55.065	0.010	22 7 55	0.96	17 21 27.308
795		29.10	2 52 24.387	0.010	77 55 30	0.14	17 21 28.595
797		29.30	2 56 38.829	0.013	30 1 17	0.91	17 21 27.421
803		29.35	3 3 12.769	0.009	62 22 27	0.46	17 21 27.846
804		29.50	3 5 35.390	0.008	19 35 23	0.98	17 21 27.340
809		29.70	3 13 49.466	0.006	70 20 31	0.28	17 21 28.044
1570		29.75	3 21 11.401	0.016	19 5 34	0.98	17 21 27.387
817	W	29.80	3 26 57.781	0.007	71 4 54	0.27	17 21 28.029
1572		29.95	3 29 45.443	0.008	60 53 25	0.49	17 21 27.788
1575		29.95	3 33 22.262	0.013	29 56 27	0.91	17 21 27.425
1578		30.05	3 37 56.727	0.007	73 27 58	0.21	17 21 28.179
826		30.05	3 44 21.825	0.013	12 52 46	0.99	17 21 27.353
830		30.05	3 49 11.145	0.012	62 32 30	0.45	17 21 27.871
837		30.25	3 54 32.359	0.013	72 5 42	0.25	17 21 28.208
843		30.25	4 4 42.731	0.011	11 57 9	1.00	17 21 27.367
847	E	30.25	4 12 56.045	0.010	58 9 33	0.55	17 21 28.373
1594		30.40	4 17 1.195	0.007	75 58 7	0.16	17 21 29.465
853		30.65	4 22 28.392	0.010	63 19 28	0.44	17 21 28.491
857		30.40	4 26 14.794	0.014	29 57 34	0.91	17 21 27.844
859		30.60	4 29 42.179	0.015	23 18 7	0.96	17 21 27.806
863		30.85	4 33 27.859	0.009	65 56 14	0.38	17 21 28.791
1600		30.85	4 38 16.398	0.010	36 48 36	0.85	17 21 27.934
870		30.90	4 46 52.974	0.011	27 48 41	0.93	17 21 27.869

STATION. . . . . : ZIERIKZEE.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : OKT 4 - 5, 1949 (II).
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H 0 M: 17 5 48.298
CHRON. RATE DIT. . . . : -0.090/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 39 4.346
LONGITUDE. . . . . . . : -0 15 39.598

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
875	E	29.70	4 56 22.105	0.013	56 53 31	0.57	17 21 28.337
880		29.80	5 3 38.883	0.014	23 28 0	0.96	17 21 27.831
882		29.90	5 8 4.776	0.012	61 60 28	0.47	17 21 28.473
885		29.80	5 12 5.528	0.009	12 29 5	1.00	17 21 27.754
1616		29.80	5 17 37.278	0.012	39 57 38	0.82	17 21 28.058
893		29.95	5 22 42.936	0.006	77 21 9	0.14	17 21 29.511
895		30.10	5 30 55.047	0.010	67 31 42	0.34	17 21 28.682
899		29.75	5 37 16.049	0.009	57 13 15	0.57	17 21 28.309
1629	W	29.75	5 40 36.140	0.011	24 51 49	0.95	17 21 27.451
2		29.95	5 51 51.758	0.011	58 52 25	0.53	17 21 27.593
7		30.05	5 56 0.670	0.011	14 54 22	0.99	17 21 27.487
1005		30.10	6 1 2.766	0.010	36 30 30	0.85	17 21 27.532
1009		30.25	6 3 48.583	0.010	37 41 30	0.84	17 21 27.562
1012		30.40	6 10 55.327	0.012	16 10 9	0.99	17 21 27.485
16		30.40	6 15 26.443	0.008	62 39 19	0.45	17 21 27.614
21		30.50	6 22 55.992	0.008	56 15 46	0.58	17 21 27.621
24	W	30.55	6 27 34.985	0.007	74 42 49	0.19	17 21 27.861
1020		30.65	6 31 36.106	0.010	16 40 18	0.99	17 21 27.485
32		30.75	6 38 54.314	0.013	60 26 44	0.50	17 21 27.675
1028		30.90	6 47 39.409	0.011	14 40 42	0.99	17 21 27.467
1032		31.00	6 53 57.185	0.012	20 46 11	0.97	17 21 27.496
45		31.20	7 1 52.857	0.010	26 60 8	0.93	17 21 27.510
46		31.05	7 7 31.528	0.008	67 52 6	0.34	17 21 27.714
1042		31.05	7 12 36.855	0.007	70 0 24	0.29	17 21 27.759
51	E	29.50	7 19 35.042	0.008	72 47 3	0.23	17 21 28.826
55		29.70	7 23 42.335	0.009	67 47 22	0.34	17 21 28.550
1050		29.55	7 30 33.097	0.013	16 42 30	0.99	17 21 27.872
63		29.55	7 35 50.327	0.009	63 25 24	0.43	17 21 28.284
70		29.85	7 44 9.720	0.006	72 10 43	0.24	17 21 28.724
74		29.75	7 49 22.948	0.012	23 13 40	0.96	17 21 27.894
1056		29.75	7 52 52.466	0.012	19 15 59	0.98	17 21 27.870
1059		29.75	7 57 52.791	0.011	24 48 47	0.95	17 21 27.884

LONGITUDE BY MERIDIAN TRANSIT OF STARS.

STATION. . . . . : GOEDEREEOE.
INSTRUMENT . . . . . . : PISTOR ANO MARTINS (1869).
DATE . . . . : JUNE 6 – 7, 1950.
OBSERVERS. . . . . . . : BRUINS/DE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H O M: 6 25 45.538
CHRON. RATE OIT. . . . : +0.109/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 49 9.70
LONGITUOE. . . . . . . : -0 15 54.24

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
1396	E	31.10	15 24 33.387	0.017	25 3 39	0.94	6 41 39.533
565		31.45	15 33 28.969	0.016	67 32 10	0.34	6 41 41.622
569		31.50	15 40 12.062	0.012	72 0 42	0.25	6 41 42.355
571		31.45	15 43 12.814	0.013	59 8 24	0.53	6 41 40.787
578		31.65	15 51 56.880	0.018	26 52 48	0.94	6 41 39.609
587		31.45	16 5 14.321	0.011	62 45 10	0.44	6 41 41.012
593	W	29.55	16 14 50.550	0.013	27 1 10	0.93	6 41 38.816
598		29.85	16 20 15.693	0.010	58 41 50	0.55	6 41 39.514
1421		29.90	16 25 6.963	0.010	17 10 34	0.99	6 41 38.677
606		30.15	16 31 31.348	0.012	76 0 12	0.16	6 41 40.682
612		30.20	16 38 13.193	0.010	75 52 13	0.16	6 41 40.706
619		30.35	16 47 18.805	0.011	68 52 30	0.31	6 41 39.995
1440	W	30.50	17 8 51.364	0.016	24 44 13	0.95	6 41 38.858
634		30.75	17 17 31.546	0.011	30 59 48	0.90	6 41 38.910
639		31.00	17 27 45.611	0.013	65 46 27	0.38	6 41 39.784
1454		30.90	17 37 12.664	0.023	18 6 16	0.98	6 41 38.543
664		31.20	17 56 16.867	0.010	68 46 44	0.32	6 41 39.992
670		31.35	18 1 50.900	0.010	72 10 18	0.25	6 41 40.256
675	E	30.45	18 10 38.625	0.011	76 58 6	0.14	6 41 44.264
674		29.95	18 14 47.958	0.016	29 14 58	0.92	6 41 39.783
681		30.35	18 24 32.594	0.021	28 45 7	0.92	6 41 39.765
685		30.55	18 32 31.330	0.013	64 22 39	0.41	6 41 41.493
695		30.60	18 40 50.517	0.007	72 42 32	0.23	6 41 42.725
700		30.70	18 51 1.052	0.010	77 30 24	0.13	6 41 44.207

STATION. . . . . : GOEDEREEDE.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : JUNE 15 – 16, 1950.
OBSERVERS. . . . . . . : BRUINS/OE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H O M: 4 29 26.100
CHRON. RATE DIT. . . . : +0.106/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 49 9.70
LONGITUDE. . . . . . . : -0 15 54.24

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
1396	E	29.60	16 45 29.262	0.016	25 3 39	0.94	4 45 20.257
565		30.00	16 54 24.392	0.009	67 32 10	0.34	4 45 22.341
569		29.95	17 1 7.391	0.009	72 0 42	0.25	4 45 22.975
571		29.95	17 4 8.449	0.007	59 8 24	0.53	4 45 21.480
578		29.70	17 12 52.822	0.012	26 52 48	0.94	4 45 20.226
587		30.25	17 26 9.958	0.011	62 45 10	0.44	4 45 21.741
593	W	30.25	17 35 46.453	0.015	27 1 10	0.93	4 45 19.635
598		30.15	17 41 11.904	0.010	58 41 50	0.55	4 45 19.952
1421		30.30	17 46 2.936	0.012	17 10 34	0.99	4 45 19.488
606		30.40	17 52 27.887	0.010	76 0 12	0.16	4 45 20.555
612		30.35	17 59 9.848	0.009	75 52 13	0.16	4 45 20.535
619		30.50	18 8 15.253	0.009	68 52 30	0.31	4 45 20.187
1440	W	30.55	18 29 47.392	0.011	24 44 13	0.95	4 45 19.676
634		30.50	18 38 27.638	0.013	30 59 48	0.90	4 45 19.704
639		30.40	18 48 42.109	0.009	65 46 27	0.38	4 45 20.240
1454		30.55	18 58 8.501	0.010	18 6 16	0.98	4 45 19.626
664		30.40	19 17 13.634	0.009	68 46 44	0.32	4 45 20.310
670		30.45	19 22 47.866	0.009	72 10 18	0.25	4 45 20.451
675	E	29.95	19 31 36.933	0.010	76 58 6	0.14	4 45 22.587
674		30.20	19 35 43.909	0.018	29 14 58	0.92	4 45 20.773
681		30.45	19 45 28.553	0.021	28 45 7	0.92	4 45 20.739
685		30.90	19 53 28.372	0.007	64 22 39	0.41	4 45 21.467
695		30.95	20 1 48.318	0.006	72 42 32	0.23	4 45 22.006
700		31.00	20 11 59.759	0.006	77 30 24	0.13	4 45 22.664

LONGITUOE 8Y MERIDIAN TRANSIT OF STARS.

STATION. . . . . : GOEDEREEDE.
INSTRUMENT . . . . . . : PISTOR ANO MARTINS (1869).
OATE . . . . : JUNE 28 – 29, 1950.
OBSERVERS. . . . . . . : 8RUINS/OE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H O M: 4 50 17.444
CHRON. RATE DIT. . . . : +0.105/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 49 9.70
LONGITUDE. . . . . . . : -0 15 54.24

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
1396	E	30.15	15 33 30.855	0.011	25 3 39	0.94	5 6 11.790
565		30.45	15 42 26.640	0.009	67 32 10	0.34	5 6 12.928
569		30.75	15 49 9.849	0.009	72 0 42	0.25	5 6 13.366
571		30.75	15 52 10.425	0.016	59 8 24	0.53	5 6 12.553
578		30.55	15 60 54.473	0.012	26 52 48	0.94	5 6 11.755
587		30.90	16 14 12.084	0.010	62 45 10	0.44	5 6 12.634
593	W	29.85	16 23 48.045	0.012	27 1 10	0.93	5 6 11.194
598		28.95	16 29 13.493	0.010	58 41 50	0.55	5 6 11.558
1421		29.90	16 34 4.488	0.008	17 10 34	0.99	5 6 11.114
606		29.85	16 40 29.563	0.007	76 0 12	0.16	5 6 11.657
612		30.00	16 47 11.477	0.009	75 52 13	0.16	5 6 11.627
619		29.70	16 56 16.934	0.008	68 52 30	0.31	5 6 11.578
1440	W	30.35	17 17 49.058	0.019	24 44 13	0.95	5 6 11.205
634		30.20	17 26 29.311	0.008	30 59 48	0.90	5 6 11.236
639		30.25	17 36 43.870	0.009	65 46 27	0.38	5 6 11.516
1454		30.35	17 46 10.208	0.010	18 6 16	0.98	5 6 11.158
664		30.05	18 5 15.506	0.010	68 46 44	0.32	5 6 11.581
670		30.00	18 10 49.812	0.008	72 10 18	0.25	5 6 11.667
675	E	30.25	18 15 38.295	0.008	76 58 6	0.14	5 6 14.305
674		29.80	18 23 46.083	0.012	29 14 58	0.92	5 6 11.797
681		30.40	18 33 30.715	0.013	28 45 7	0.92	5 6 11.833
685		30.55	18 41 30.260	0.010	64 22 39	0.41	5 6 12.679
695		30.60	18 49 49.911	0.010	72 42 32	0.23	5 6 13.442
700		30.75	18 60 1.127	0.008	77 30 24	0.13	5 6 14.334

STATION. . . . . : GOEDEREEOE.
INSTRUMENT . . . . . . : PISTOR AND MARTINS (1869).
DATE . . . . : JUNE 29 – 30, 1950.
OBSERVERS. . . . . . . : BRUINS/OE VRIES.

CHRON. CORRECTION
SIGNAL(GBR)-T AT 20H O M: 4 50 17.600
CHRON. RATE DIT. . . . : +0.110/14H

APPROXIMATE VALUES:
LATITUDE . . . . : 51 49 9.70
LONGITUOE. . . . . . . : -0 15 54.24

OBSERVATIONS:

STAR		LEVEL	CHRON. TIME	SIGMA	DEC.	G	(RA-T)
1396	E	29.60	15 29 34.208	0.014	25 3 39	0.94	5 6 12.452
565		29.75	15 38 30.284	0.009	67 32 10	0.34	5 6 13.125
569		29.80	15 45 13.560	0.010	72 0 42	0.25	5 6 13.350
571		29.90	15 48 14.003	0.009	59 8 24	0.53	5 6 12.846
578		29.85	15 56 57.741	0.012	26 52 48	0.94	5 6 12.484
587		30.05	16 10 15.786	0.021	62 45 10	0.44	5 6 12.778
593	W	30.40	16 19 51.822	0.012	27 1 10	0.93	5 6 11.431
598		30.35	16 25 17.767	0.008	58 41 50	0.55	5 6 11.040
1421		30.55	16 30 8.142	0.011	17 10 34	0.99	5 6 11.477
606		30.60	16 36 34.768	0.009	76 0 12	0.16	5 6 10.149
612		30.70	16 43 16.710	0.009	75 52 13	0.16	5 6 10.114
619		30.65	16 52 21.609	0.010	68 52 30	0.31	5 6 10.663
1440	W	31.75	17 13 52.788	0.010	24 44 13	0.95	5 6 11.400
634		31.85	17 22 33.013	0.015	30 59 48	0.90	5 6 11.410
639		31.60	17 32 48.237	0.008	65 46 27	0.38	5 6 10.843
1454		31.70	17 42 13.852	0.012	18 6 16	0.98	5 6 11.465
664		31.90	18 1 19.823	0.006	68 46 44	0.32	5 6 10.768
670		32.00	18 6 54.245	0.009	72 10 18	0.25	5 6 10.591
675	E	30.00	18 15 42.616	0.010	76 58 6	0.14	5 6 13.915
674		30.55	18 19 49.582	0.016	29 14 58	0.92	5 6 12.476
681		30.60	18 29 34.158	0.013	28 45 7	0.92	5 6 12.499
685		30.95	18 37 33.988	0.015	64 22 39	0.41	5 6 13.127
695		31.20	18 45 53.920	0.007	72 42 32	0.23	5 6 13.715
700		31.30	18 56 5.402	0.008	77 30 24	0.13	5 6 14.375

Appendix II

LATITUDE, LONGITUDE AND AZIMUTH

DETERMINATION BY THE BLACK METHOD.

STATION. . . . .: UBACHSBERG.
REFERENCE MARK . . . .: SCHIMMERT.
INSTRUMENT . . . .: WILD T4/1957.
DATE . . . .: JUNE - JULY, 1968
OBSERVER . . . .: VAN LOON.

APPROXIMATE VALUES:

LATITUDE . . . .: 50° 50' 50".700
LONGITUDE. . . . .: -0^h 23^m $48^s.000$
AZIMUTH. . . . .: 303° 5' 5".000

OBSERVATIONS:

DATE	STAR	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME			CHR.CORR.(UTC-T)		
VI.11	1568	1	303°	5'	18".920	52°	9'	36".060	47.4	5^h	29^m	$44^s.788$	15^h	40^m	$58^s.163$
		1	303	5	18.800	52	26	10.300	47.4	5	31	42.371	15	40	58.163
		2	123	5	22.920	233	33	30.040	51.4	5	39	40.800	15	40	58.165
		2	123	5	22.820	233	49	53.810	51.0	5	41	37.753	15	40	58.165
	17	1	303	5	18.500	38	51	6.030	46.1	7	40	51.790	15	40	58.184
		1	303	5	18.280	39	8	59.830	45.9	7	43	13.939	15	40	58.184
		2	123	5	22.610	220	5	36.040	51.1	7	50	45.704	15	40	58.186
		2	123	5	22.700	220	22	16.150	50.8	7	52	59.765	15	40	58.186
	585	1	348	5	18.580	257	42	36.050	49.4	8	12	26.982	15	40	58.190
		1	348	5	18.480	258	3	23.800	49.5	8	13	42.906	15	40	58.190
		2	168	5	22.650	80	23	30.040	46.9	8	22	19.337	15	40	58.192
		2	168	5	22.730	80	44	14.430	46.8	8	23	36.561	15	40	58.192
VI.12	441	1	33	5	18.540	39	8	36.050	45.4	8	49	26.338	15	40	58.196
		1	33	5	18.320	39	23	59.510	45.3	8	51	21.056	15	40	58.196
		2	213	5	22.420	220	29	24.030	51.1	8	59	26.464	15	40	58.198
		2	213	5	22.400	220	44	33.390	50.6	9	1	18.703	15	40	58.198
	1574	1	78	5	18.300	261	25	18.070	49.7	9	19	27.593	15	40	58.202
		1	78	5	18.300	261	45	17.400	49.6	9	20	48.782	15	40	58.202
		2	258	5	22.280	83	56	.040	47.2	9	29	32.858	15	40	58.204
		2	258	5	22.200	84	18	21.580	47.0	9	31	1.416	15	40	58.204
VI.14	1480	1	33	5	20.420	227	59	48.040	47.0	5	1	41.700	17	6	2.724
		1	33	5	20.500	228	22	20.310	47.0	5	3	8.455	17	6	2.725
		2	213	5	15.100	50	38	24.060	49.5	5	11	46.751	17	6	2.726
		2	213	5	14.840	50	59	2.380	49.8	5	13	4.432	17	6	2.726
	516	1	78	5	20.450	1	34	42.040	48.5	5	30	53.215	17	6	2.730
		1	78	5	20.630	1	56	20.310	48.6	5	32	16.527	17	6	2.730
		2	258	5	15.280	184	6	48.020	49.1	5	40	45.010	17	6	2.731
		2	258	5	15.400	184	28	15.840	48.8	5	42	9.629	17	6	2.731
	17	1	303	5	20.700	38	51	6.030	47.9	6	3	59.538	17	6	2.735
		1	303	5	20.980	39	5	53.120	47.6	6	5	57.015	17	6	2.735
		2	123	5	15.480	220	5	36.070	47.9	6	13	55.112	17	6	2.737
		2	123	5	15.400	220	20	10.140	47.9	6	15	52.313	17	6	2.737
	585	1	348	5	20.880	257	42	36.100	47.7	6	35	34.311	17	6	2.741
		1	348	5	20.920	258	2	25.600	47.7	6	36	46.750	17	6	2.741
		2	168	5	15.500	80	23	30.030	49.0	6	45	27.441	17	6	2.742
		2	168	5	15.420	80	43	18.250	49.0	6	46	41.097	17	6	2.742
VI.15	441	1	33	5	20.890	39	8	36.070	48.0	7	12	33.586	17	6	2.747
		1	33	5	20.760	39	24	8.810	48.0	7	14	29.625	17	6	2.747
		2	213	5	15.380	220	29	24.030	48.9	7	22	35.205	17	6	2.749
		2	213	5	15.420	220	46	55.350	48.3	7	24	44.692	17	6	2.749
	1574	1	78	5	20.790	261	47	7.830	47.4	7	44	3.687	17	6	2.753
		1	78	5	20.880	262	8	17.900	47.5	7	45	29.279	17	6	2.753
		2	258	5	15.520	83	56	.040	49.2	7	52	40.582	17	6	2.754
		2	258	5	15.320	84	16	24.400	49.3	7	54	1.737	17	6	2.754
	456	1	348	5	20.820	9	45	54.070	47.5	8	45	56.490	17	6	2.763
		1	348	5	20.650	10	0	35.250	47.4	8	48	1.745	17	6	2.764
		2	168	5	15.470	190	56	54.020	48.3	8	55	59.569	17	6	2.765
		2	168	5	15.620	191	12	1.380	48.0	8	58	6.918	17	6	2.765
VI.18	17	1	303	5	20.450	38	51	6.030	47.4	0	27	22.519	22	26	56.381
		1	303	5	20.180	39	5	45.540	47.5	0	29	18.999	22	26	56.382
		2	123	5	15.180	220	5	36.010	50.6	0	37	18.110	22	26	56.383
		2	123	5	14.980	220	20	27.510	50.6	0	39	17.594	22	26	56.383
	585	1	348	5	20.420	257	42	36.030	48.9	0	58	57.104	22	26	56.387
		1	348	5	20.440	258	2	5.830	49.0	1	0	8.300	22	26	56.387
		2	168	5	15.140	80	23	30.030	49.2	1	8	50.204	22	26	56.389
		2	168	5	15.280	80	43	44.140	49.0	1	10	5.609	22	26	56.389

DATE	STAR	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME			CHR.CORR.(UTC-T)		
VI.19	441	1	33	5	20.620	39	8	36.020	49.4	1	35	56.352	22	26	56.393
		1	33	5	20.900	39	22	53.010	49.2	1	37	42.945	22	26	56.393
		2	213	5	15.420	220	29	24.060	50.0	1	45	57.830	22	26	56.395
		2	213	5	15.300	220	44	45.300	49.5	1	47	51.463	22	26	56.395
	850	1	78	5	20.800	268	34	19.100	48.0	3	16	15.601	22	26	56.410
		1	78	5	20.640	268	55	22.480	48.2	3	17	38.105	22	26	56.410
		2	258	5	15.430	90	55	36.030	51.1	3	25	24.741	22	26	56.411
		2	258	5	15.410	91	15	14.400	51.4	3	26	40.154	22	26	56.412
VI.21	525	1	325	5	20.820	225	43	18.080	50.0	1	11	30.802	19	59	59.219
		1	325	5	20.610	226	3	27.300	49.9	1	12	42.723	19	59	59.219
		2	145	5	25.320	48	28	36.040	49.8	1	21	24.407	19	59	59.221
		2	145	5	25.100	48	50	21.330	49.8	1	22	43.221	19	59	59.221
	412	1	10	5	20.910	354	16	.030	49.7	1	49	54.808	19	59	59.226
		1	10	5	20.780	354	32	6.500	49.9	1	51	32.062	19	59	59.226
		2	190	5	25.320	175	54	36.030	50.7	1	59	50.778	19	59	59.228
		2	190	5	25.260	176	11	12.410	50.5	2	1	31.503	19	59	59.228
	63	1	55	5	20.810	132	50	18.040	49.6	2	23	32.280	19	59	59.232
		1	55	5	20.640	133	4	24.880	49.5	2	25	39.701	19	59	59.232
		2	235	5	25.220	313	55	54.020	52.1	2	33	25.670	19	59	59.233
		2	235	5	25.020	314	11	4.000	51.7	2	35	44.295	19	59	59.234
	1555	1	100	5	20.810	267	46	.030	49.6	2	58	6.600	19	59	59.238
		1	100	5	20.830	268	5	27.700	49.6	2	59	33.000	19	59	59.238
		2	280	5	25.200	90	3	42.020	51.5	3	8	11.191	19	59	59.239
		2	280	5	25.250	90	23	54.560	51.4	3	9	38.806	19	59	59.239
	605	1	303	5	20.790	208	23	48.040	49.3	3	28	48.586	19	59	59.243
		1	303	5	20.780	208	44	.080	49.4	3	30	1.511	19	59	59.243
		2	123	5	25.190	31	6	54.020	50.9	3	38	41.194	19	59	59.245
		2	123	5	25.120	31	29	9.170	50.8	3	40	2.909	19	59	59.245
VI.22	470	1	348	5	20.660	343	46	.040	50.2	4	4	26.466	19	59	59.249
		1	348	5	20.540	344	4	16.510	50.2	4	6	29.900	19	59	59.249
		2	168	5	24.980	165	14	48.040	49.2	4	14	24.854	19	59	59.250
		2	168	5	25.090	165	30	58.900	49.0	4	16	13.830	19	59	59.251
	122	1	33	5	20.810	118	10	36.040	50.7	4	41	48.250	19	59	59.255
		1	33	5	20.730	118	25	50.780	50.5	4	43	59.497	19	59	59.256
		2	213	5	25.280	299	19	18.030	50.4	4	51	41.749	19	59	59.257
		2	213	5	25.030	299	47	35.560	50.1	4	55	49.183	19	59	59.258
	1606	1	78	5	21.120	248	37	.020	48.1	5	7	20.535	19	59	59.259
		1	78	5	21.280	248	54	26.480	48.2	5	8	36.587	19	59	59.260
		2	258	5	25.410	70	57	18.030	52.1	5	17	25.588	19	59	59.261
		2	258	5	25.280	71	15	16.500	52.2	5	18	42.114	19	59	59.261
VI.26	1555	1	100	5	4.890	267	46	.050	51.2	0	38	28.937	21	59	58.826
		1	100	5	4.840	268	5	34.460	51.2	0	39	55.777	21	59	58.826
		2	280	4	59.840	90	3	42.030	50.5	0	48	34.334	21	59	58.828
		2	280	4	59.800	90	22	50.380	50.5	0	49	57.257	21	59	58.828
	605	1	303	5	5.880	208	23	48.030	52.0	1	9	10.317	21	59	58.832
		1	303	5	5.780	208	48	36.340	52.1	1	10	39.852	21	59	58.832
		2	123	5	.680	31	6	54.040	50.1	1	19	3.653	21	59	58.834
		2	123	5	.940	31	31	10.330	50.0	1	20	32.788	21	59	58.834
	470	1	348	5	5.890	343	46	.040	48.9	1	44	48.565	21	59	58.838
		1	348	5	5.900	344	3	2.100	48.9	1	46	43.571	21	59	58.838
		2	168	5	.880	165	14	48.020	52.5	1	54	48.044	21	59	58.840
		2	168	5	1.010	165	33	1.350	52.5	1	56	50.895	21	59	58.840
VII.1	32	1	55	5	5.610	138	50	24.040	48.1	1	24	5.466	19	59	43.284
		1	55	5	5.900	139	6	31.120	48.0	1	26	25.880	19	59	43.284
		2	235	5	.780	319	58	48.030	51.6	1	34	3.302	19	59	43.285
		2	235	5	.830	320	14	55.100	51.7	1	36	25.152	19	59	43.285
VII.3	899	1	303	5	5.890	32	42	48.030	48.1	0	44	59.904	20	0	1.135
		1	303	5	6.060	32	59	18.880	47.9	0	47	17.696	20	0	1.135
		2	123	5	7.020	213	53	42.020	49.7	0	54	53.909	20	0	1.137
		2	123	5	7.180	214	13	26.430	49.5	0	57	40.960	20	0	1.137
	1276	1	33	5	5.770	36	34	6.020	46.9	1	52	23.752	20	0	1.146
		1	33	5	6.100	36	50	37.580	46.4	1	54	23.812	20	0	1.146
		2	213	5	6.980	217	56	48.030	50.5	2	2	24.337	20	0	1.147
		2	213	5	6.650	218	14	15.000	50.1	2	4	30.629	20	0	1.147
	585	1	78	5	5.880	347	42	36.020	47.3	2	26	54.430	20	0	1.151
		1	78	5	5.530	348	2	23.420	46.9	2	28	6.728	20	0	1.151
		2	258	5	6.480	170	23	30.020	49.1	2	36	47.174	20	0	1.153
		2	258	5	6.580	170	51	18.720	48.7	2	38	30.852	20	0	1.153
	1533	1	325	5	5.670	162	55	6.030	48.7	3	2	5.171	20	0	1.157
		1	325	5	5.620	163	17	33.360	48.8	3	3	30.522	20	0	1.157
		2	145	5	6.660	345	35	30.040	48.8	3	12	9.931	20	0	1.158
		2	145	5	6.440	345	59	32.740	48.4	3	13	39.517	20	0	1.158
	588	1	10	5	5.860	300	16	36.020	46.4	3	30	56.039	20	0	1.161
		1	10	5	5.920	300	43	24.210	46.3	3	32	42.654	20	0	1.161
		2	190	5	6.890	122	43	42.020	49.7	3	40	47.337	20	0	1.163
		2	190	5	6.890	123	7	29.960	49.7	3	42	24.318	20	0	1.163
VII.4	1045	1	55	5	5.790	170	45	.030	49.4	4	7	29.340	20	0	1.167
		1	55	5	5.640	171	4	41.260	49.6	4	9	40.963	20	0	1.167
		2	235	5	6.540	352	14	12.030	48.5	4	17	26.963	20	0	1.168
		2	235	5	6.650	352	31	28.750	48.2	4	19	22.962	20	0	1.168
	456	1	100	5	5.710	121	45	54.040	46.8	4	37	17.088	20	0	1.171
		1	100	5	5.680	122	2	19.810	46.6	4	39	37.167	20	0	1.172
		2	280	5	6.520	302	56	54.030	49.9	4	47	19.428	20	0	1.173
		2	280	5	6.490	303	13	11.570	49.7	4	49	36.430	20	0	1.173
	892	1	348	5	5.510	164	57	42.030	49.2	5	6	52.673	20	0	1.176
		1	348	5	5.820	165	22	43.970	49.4	5	8	37.843	20	0	1.176
		2	168	5	6.390	347	23	18.030	46.5	5	16	58.358	20	0	1.178
		2	168	5	6.680	347	46	38.940	46.8	5	18	34.158	20	0	1.178

LATITUDE, LONGITUDE AND AZIMUTH

DETERMINATION BY THE BLACK METHOD.

STATION. . . . .: TONGEREN.
REFERENCE MARK . . . .: HERDEREN.
INSTRUMENT . . . .: WILD T4/1957.
DATE . . . .: MAY - JUNE, 1968
OBSERVER . . . .: VAN LOON.

APPROXIMATE VALUES:

LATITUDE . . . .: 50° 46' 56".100
LONGITUDE. . . . .: -0^h 21^m $51^s.160$
AZIMUTH. . . . .: 68° 46' 30".000

OBSERVATIONS:

DATE	STAR	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME			CHR.CORR.(UTC-T)		
V.14	182	1	68°	46'	27".320	330°	43'	4".280	46.8	2^h	21^m	$11^s.194$	18^h	53^m	$12^s.345$
		1	68	46	27.380	330	59	13.740	46.7	2	23	34.766	18	53	12.346
		2	248	46	20.960	151	41	30.020	51.6	2	29	50.004	18	53	12.348
		2	248	46	20.920	151	57	19.180	51.5	2	32	8.912	18	53	12.348
	740	1	113	46	27.300	109	56	24.020	47.0	3	1	18.689	18	53	13.539
		1	113	46	27.320	110	15	9.540	46.6	3	3	17.690	18	53	13.539
		2	293	46	20.880	291	30	48.160	51.2	3	11	18.238	18	53	13.540
		2	293	46	20.850	291	51	51.680	50.8	3	13	31.771	18	53	13.541
	418	1	158	46	27.040	329	42	12.030	51.0	3	29	39.563	18	53	13.544
		1	158	46	26.980	330	5	22.120	51.0	3	31	15.158	18	53	13.544
		2	338	46	20.340	152	4	.080	47.0	3	39	31.252	18	53	13.545
		2	338	46	20.280	152	27	39.830	47.0	3	41	11.246	18	53	13.546
	1445	1	203	46	27.320	279	28	24.120	53.0	4	10	56.111	18	53	13.551
		1	203	46	27.280	279	51	36.190	52.7	4	12	23.223	18	53	13.551
		2	23	46	20.680	102	10	36.100	46.2	4	21	.635	18	53	13.552
		2	23	46	20.650	102	32	6.500	46.1	4	22	19.849	18	53	13.552
	525	1	90	46	26.940	225	58	6.080	54.5	4	50	28.355	18	53	13.557
		1	90	46	26.920	226	18	22.660	54.1	4	51	40.788	18	53	13.557
		2	270	46	20.180	48	43	12.060	45.6	5	0	22.741	18	53	13.599
		2	270	46	20.320	49	4	39.580	45.2	5	1	40.542	18	53	13.559
V.15	412	1	135	46	27.290	354	16	54.030	48.3	5	27	55.199	18	53	13.564
		1	135	46	27.300	354	35	45.800	48.0	5	29	49.239	18	53	13.564
		2	315	46	20.680	176	4	58.600	51.7	5	38	51.342	18	53	13.565
		2	315	46	20.740	176	22	19.900	51.7	5	40	36.975	18	53	13.566
	63	1	180	46	26.880	132	56	18.100	43.5	6	2	40.704	18	53	13.570
		1	180	46	26.820	133	14	16.440	43.3	6	5	23.119	18	53	13.570
		2	0	46	20.180	314	1	42.090	53.5	6	12	36.361	18	53	13.571
		2	0	46	20.280	314	15	36.080	53.0	6	14	43.660	18	53	13.571
V.23	741	1	203	46	27.580	244	39	54.020	48.3	1	42	44.209	21	44	22.450
		1	203	46	27.780	245	0	23.340	48.1	1	44	15.810	21	44	22.450
		2	23	46	21.000	66	56	36.100	48.7	1	52	50.168	21	44	22.451
		2	23	46	21.320	67	17	37.220	48.8	1	54	21.914	21	44	22.451
V.24	17	1	68	46	28.030	38	53	24.140	48.0	2	54	36.797	21	44	22.461
		1	68	46	27.900	39	9	59.680	47.9	2	56	48.757	21	44	22.461
		2	248	46	21.300	220	7	48.080	48.7	3	4	33.063	21	44	22.463
		2	248	46	21.200	220	23	48.150	48.4	3	6	41.869	21	44	22.463
	585	1	113	46	27.380	257	53	24.040	47.5	3	26	16.839	21	44	22.466
		1	113	46	27.500	258	15	55.830	47.6	3	27	39.238	21	44	22.466
		2	293	46	20.880	80	34	6.080	47.2	3	36	10.030	21	44	22.468
		2	293	46	20.830	80	57	58.600	47.2	3	37	38.934	21	44	22.468
	441	1	158	46	27.380	39	7	36.080	47.4	4	2	21.659	21	44	22.472
		1	158	46	27.480	39	25	13.920	47.5	4	4	33.405	21	44	22.472
		2	338	46	20.680	220	28	8.050	48.2	4	12	22.865	21	44	22.474
		2	338	46	20.700	220	49	15.780	48.0	4	14	59.266	21	44	22.474
	1157	1	68	46	27.980	322	2	42.040	48.3	1	32	51.118	19	9	54.825
		1	68	46	27.920	322	21	36.600	48.2	1	35	29.293	19	9	54.625
		2	248	46	21.320	143	15	6.080	50.6	1	42	55.131	19	9	54.827
		2	248	46	21.280	143	32	40.640	50.8	1	45	20.167	19	9	54.828

DATE	STAR	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME			CHR.CORR.(UTC-T)		
V.24	603	1	113	46	27.020	187	38	12.020	51.6	2	22	20.596	19	9	54.834
		1	113	46	27.300	188	0	11.200	51.6	2	23	43.626	19	9	54.834
		2	293	46	20.300	10	19	24.100	47.3	2	32	25.120	19	9	54.835
		2	293	46	20.540	10	43	13.340	46.9	2	33	53.370	19	9	54.836
	792	1	158	46	27.040	144	45	48.080	47.5	2	53	39.005	19	9	54.839
		1	158	46	27.030	145	2	45.830	47.5	2	55	36.691	19	9	54.840
		2	338	46	20.360	326	11	30.060	47.8	3	3	36.372	19	9	54.841
		2	338	46	20.300	326	30	14.310	47.6	3	5	47.085	19	9	54.841
	1317	1	203	46	28.040	5	56	36.060	48.5	3	23	29.598	19	9	54.844
		1	203	46	27.780	6	17	46.480	48.4	3	24	52.856	19	9	54.844
		2	23	46	21.320	188	25	24.030	49.5	3	33	21.230	19	9	54.846
		2	23	46	21.020	188	48	13.620	49.4	3	34	53.256	19	9	54.846
	525	1	91	46	27.640	226	58	6.100	50.0	3	54	27.848	19	9	54.850
		1	91	46	27.620	227	24	34.680	50.2	3	56	2.444	19	9	54.850
		2	271	46	21.050	49	43	12.020	47.5	4	4	22.252	19	9	54.852
		2	271	46	21.020	50	7	14.130	47.6	4	5	49.364	19	9	54.852
	412	1	136	46	27.730	355	16	54.100	46.5	4	31	54.754	19	9	54.856
		1	136	46	27.620	355	37	23.420	46.6	4	33	58.703	19	9	54.857
		2	316	46	20.960	176	55	24.030	51.7	4	41	52.520	19	9	54.858
		2	316	46	20.990	177	15	20.180	51.5	4	43	53.752	19	9	54.858
V.25	63	1	181	46	27.700	133	56	18.070	47.8	5	6	40.998	19	9	54.862
		1	181	46	27.630	134	12	16.840	47.8	5	9	5.551	19	9	54.863
		2	1	46	21.020	315	1	42.020	48.3	5	16	36.627	19	9	54.864
		2	1	46	20.990	315	17	17.700	48.1	5	18	59.412	19	9	54.864
	1555	1	226	46	27.700	268	41	36.080	48.9	5	40	2.329	19	9	54.868
		1	226	46	27.680	269	8	54.810	48.9	5	42	3.723	19	9	54.868
		2	46	46	21.000	90	59	12.040	49.9	5	50	8.295	19	9	54.870
		2	46	46	21.110	91	24	32.480	49.9	5	51	58.195	19	9	54.870
V.30	740	1	68	46	28.250	64	56	24.000	48.7	1	37	38.308	19	14	.455
		1	68	46	28.160	65	16	20.590	48.6	1	39	44.771	19	14	.455
		2	248	46	21.630	246	30	48.020	48.7	1	47	37.764	19	14	.457
		2	248	46	21.320	246	50	18.110	48.7	1	49	41.204	19	14	.457
	418	1	113	46	27.420	284	42	12.040	48.9	2	5	57.711	19	14	.460
		1	113	46	27.300	285	5	48.040	49.2	2	7	35.075	19	14	.460
		2	293	46	20.700	107	4	.030	48.2	2	15	49.157	19	14	.462
		2	293	46	20.680	107	33	6.830	47.9	2	17	52.294	19	14	.462
	1445	1	158	46	26.400	234	28	24.050	52.6	2	47	15.187	19	14	.468
		1	158	46	27.540	234	52	45.370	52.7	2	48	46.524	19	14	.468
		2	338	46	18.280	57	10	36.050	44.0	2	57	19.534	19	14	.469
		2	338	46	19.230	57	33	8.120	43.9	2	58	42.492	19	14	.469
	292	1	203	46	28.320	102	33	6.030	42.6	3	19	27.127	19	14	.473
		1	203	46	27.630	102	49	14.740	42.6	3	21	47.849	19	14	.473
		2	23	46	21.850	283	42	36.060	52.7	3	29	31.476	19	14	.475
		2	23	46	21.100	283	58	57.800	52.4	3	31	52.227	19	14	.475
	899	1	91	46	28.020	55	46	.030	48.6	3	47	13.354	19	14	.478
		1	91	46	28.350	56	2	23.330	48.6	3	49	30.371	19	14	.478
		2	271	46	21.550	236	56	48.010	46.6	3	57	9.002	19	14	.480
		2	271	46	21.680	237	12	57.200	46.6	3	59	25.872	19	14	.480
	749	1	136	46	27.960	186	1	30.030	49.4	4	18	50.043	19	14	.484
		1	136	46	27.640	186	28	44.520	49.4	4	20	45.718	19	14	.484
		2	316	46	21.300	8	25	30.010	49.5	4	28	56.305	19	14	.487
		2	316	46	21.080	8	49	55.310	49.3	4	30	37.638	19	14	.487
V.31	1276	1	181	46	27.800	59	33	24.040	49.0	4	53	44.083	19	14	.490
		1	181	46	27.820	59	52	41.610	48.8	4	56	4.717	19	14	.490
		2	1	46	21.210	240	55	54.010	48.6	5	3	44.954	19	14	.492
		2	1	46	21.120	241	13	5.940	48.6	5	5	49.541	19	14	.492
	585	1	226	46	27.830	10	53	24.020	47.2	5	29	7.663	19	14	.496
		1	226	46	27.900	11	15	55.080	47.2	5	30	30.046	19	14	.496
		2	46	46	21.380	193	34	6.000	49.5	5	39	.643	19	14	.498
		2	46	46	21.190	193	58	25.560	49.2	5	40	31.288	19	14	.498
VI.5	525	1	90	46	27.690	226	10	15.720	48.1	9	32	34.696	12	45	20.387
		1	90	46	27.720	226	46	35.600	48.9	9	34	44.829	12	45	20.387
		2	270	46	21.120	48	43	12.040	49.5	9	41	45.481	12	45	20.388
		2	270	46	21.090	49	8	38.490	49.2	9	43	17.758	12	45	20.388
	412	1	135	46	28.040	354	16	54.040	49.1	10	9	18.042	12	45	20.393
		1	135	46	28.040	354	35	5.780	49.2	10	11	8.191	12	45	20.393
		2	315	46	21.380	175	55	24.080	50.4	10	19	15.727	12	45	20.394
		2	315	46	21.460	176	13	50.980	50.1	10	21	7.933	12	45	20.395
	63	1	180	46	28.020	133	11	44.310	48.3	10	46	24.371	12	45	20.399
		1	180	46	28.140	133	29	29.630	48.3	10	49	5.503	12	45	20.399
		2	0	46	21.420	314	1	42.060	50.1	10	53	59.958	12	45	20.400
		2	0	46	21.500	314	16	19.250	49.8	10	56	13.834	12	45	20.400
VI.6	768	1	225	46	27.900	265	25	12.030	49.0	3	7	.369	20	8	20.076
		1	225	46	28.090	265	45	45.960	48.9	3	8	33.096	20	8	20.076
		2	45	46	21.280	87	40	42.040	50.5	3	17	5.914	20	8	20.077
		2	45	46	21.440	88	6	21.230	50.3	3	18	58.838	20	8	20.077
	1531	1	203	46	27.910	255	18	42.050	47.8	3	31	31.719	20	8	20.080
		1	203	46	28.120	[illegible]	38	24.290	47.9	3	32	54.409	20	8	20.080
		2	23	46	21.300		44	30.020	50.7	3	41	37.633	20	8	20.082
		2	23	46	21.480	78	8	29.880	50.4	3	43	15.918	20	8	20.082

Appendix III

AZIMUTH BY POLARIS.

STATION. . . . .: GOEDEREEDE (PILLAR 2)
REFERENCE MARK . . . .: ZIERIKZEE (LAMP '69)
INSTRUMENT . . . .: WILD T4 /1957
DATE . . . .: 22-5 1969.
OBSERVER . . . .: STEUR.

LATITUDE . . . .: 51° 49' 9".700
LONGITUDE. . . . .: -0^h 15^m $54^s.350$
CHRONOMETER CORRECTION (UTC-T): 12 3 33.546
REFERENCE MOMENT . . . .: 6 25 26.454
CHRONOMETER RATE (SEC/HOUR). .: .008

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	192°	44'	32".580	359°	17'	51".880	43.4	7^h	41^m	$16^s.410$
	1	192	44	32.610	359	18	13.650	43.3	7	42	21.480
	2	12	44	27.580	179	18	46.780	56.4	7	44	37.560
	2	12	44	27.510	179	19	4.180	56.3	7	45	30.760
2	1	200	14	33.200	6	57	36.180	48.6	8	11	5.770
	1	200	14	32.890	6	57	57.220	48.5	8	12	3.060
	2	20	14	24.490	186	58	29.620	50.5	8	14	21.620
	2	20	14	24.630	186	58	56.720	50.5	8	15	39.600
3	1	207	44	28.220	14	41	55.510	48.4	8	52	10.830
	1	207	44	28.300	14	42	21.800	48.2	8	53	27.070
	2	27	44	24.030	194	43	23.180	48.6	8	56	54.470
	2	27	44	24.210	194	44	18.220	48.5	8	59	24.780
4	1	215	14	29.780	22	18	34.110	49.0	9	10	32.320
	1	215	14	29.100	22	18	53.220	48.8	9	11	26.780
	2	35	14	24.500	202	19	22.210	48.7	9	13	21.230
	2	35	14	24.590	202	19	54.610	48.9	9	14	47.180
5	1	222	44	28.400	30	2	44.860	46.7	9	49	14.910
	1	222	44	28.220	30	3	10.320	46.5	9	50	26.220
	2	42	44	22.520	210	3	56.900	50.8	9	53	11.760
	2	42	44	22.580	210	4	18.880	50.6	9	54	10.000
6	1	230	14	30.130	37	37	41.550	45.6	10	2	44.810
	1	230	14	30.220	37	38	2.810	45.5	10	3	42.880
	2	50	14	23.310	217	38	40.970	50.9	10	6	8.700
	2	50	14	23.280	217	39	5.800	50.8	10	7	15.360

STATION. . . . .: GOEDEREEDE (PILLAR 2)
REFERENCE MARK . . . .: ZIERIKZEE (LAMP '69)
INSTRUMENT . . . .: WILD T4 /1957
DATE . . . .: 29-5 1969.
OBSERVER . . . .: STEUR.

LATITUDE . . . .: 51 49 9.700
LONGITUDE. . . . .: -0 15 54.350
CHRONOMETER CORRECTION (UTC-T): 9 35 33.825
REFERENCE MOMENT . . . .: 18 51 .000
CHRONOMETER RATE (SEC/HOUR). .: .009

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	237	45	13.670	44	20	11.820	48.5	9	47	8.490
	1	237	45	14.670	44	20	24.990	48.5	9	47	51.720
	2	57	45	4.180	224	20	43.020	53.6	9	49	39.600
	2	57	45	4.750	224	20	58.600	53.7	9	50	28.180
2	1	245	15	8.060	51	54	58.980	46.8	10	1	54.640
	1	245	15	9.120	51	55	16.320	46.8	10	2	47.440
	2	65	14	59.230	231	55	43.080	55.6	10	4	56.420
	2	65	14	59.760	231	55	58.310	55.5	10	5	40.910
3	1	252	45	11.090	59	28	34.650	45.9	10	12	26.380
	1	252	45	11.190	59	28	48.650	45.7	10	13	6.390
	2	72	45	.420	239	29	20.330	54.8	10	15	25.390
	2	72	45	1.180	239	29	33.010	54.8	10	16	7.300
4	1	260	15	3.780	67	9	7.720	49.8	10	43	16.360
	1	260	15	4.320	67	9	24.880	49.6	10	44	6.070
	2	80	14	53.220	247	9	44.310	50.4	10	45	48.840
	2	80	14	53.800	247	9	59.300	50.2	10	46	32.100
5	1	268	15	5.020	75	12	39.800	49.2	10	53	8.150
	1	268	15	5.150	75	12	52.620	49.0	10	53	44.350
	2	88	14	53.270	255	13	13.490	51.4	10	55	31.640
	2	88	14	53.690	255	13	30.720	51.4	10	56	17.350
6	1	275	16	55.710	82	19	37.110	47.9	11	7	10.240
	1	275	16	56.110	82	19	52.080	47.9	11	7	51.010
	2	95	16	44.500	262	20	9.600	51.9	11	9	28.240
	2	95	16	45.280	262	20	25.250	51.6	11	10	8.810

AZIMUTH BY POLARIS.

STATION. . . . .: GOEDEREEDE (PILLAR 2)
REFERENCE MARK . . . .: ZIERIKZEE (LAMP '69)
INSTRUMENT . . . .: WILD T4 /1957
DATE . . . .: 3-6 1969.
OBSERVER . . . .: STEUR.

LATITUDE . . . .: 51 49 9.700
LONGITUDE. . . . .: -0 15 54.350
CHRONOMETER CORRECTION (UTC-T): 9 59 4.365
REFERENCE MOMENT . . . .: 8 8 55.635
CHRONOMETER RATE (SEC/HOUR). .: .008

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	290	15	52.990	96	44	.710	46.3	8	42	50.050
	1	290	15	53.280	96	44	13.040	46.1	8	43	31.810
	2	110	15	57.320	276	44	41.920	49.3	8	44	52.370
	2	110	15	57.830	276	45	.200	49.2	8	45	43.900
2	1	298	15	53.810	104	47	11.980	46.4	8	53	1.750
	1	298	15	54.110	104	47	47.820	46.0	8	54	50.030
	2	118	15	57.480	284	48	32.980	49.0	8	56	56.730
	2	118	15	58.080	284	49	16.380	49.3	8	59	15.170
3	1	305	15	55.760	111	58	13.500	47.4	9	26	28.150
	1	305	15	55.810	111	58	35.640	47.4	9	27	34.080
	2	125	16	.300	291	59	30.590	47.6	9	30	6.680
	2	125	16	.520	291	59	49.090	47.7	9	31	2.420
4	1	312	45	55.520	119	32	51.080	47.0	9	39	58.760
	1	312	45	55.430	119	33	7.180	47.0	9	40	50.100
	2	132	46	.820	299	34	53.520	47.4	9	45	38.010
	2	132	46	.400	299	35	15.480	47.4	9	46	41.210
5	1	320	15	57.210	127	7	42.520	47.0	9	53	51.340
	1	320	15	57.000	127	8	2.020	46.9	9	54	49.560
	2	140	16	1.010	307	8	40.780	47.7	9	56	21.800
	2	140	16	.980	307	8	56.020	48.0	9	57	2.290
6	1	327	45	57.560	134	48	20.640	47.5	10	23	27.430
	1	327	45	57.640	134	48	37.500	47.5	10	24	15.430
	2	147	46	3.710	314	49	21.610	48.4	10	26	1.730
	2	147	46	3.070	314	49	37.670	48.4	10	26	49.190

STATION. . . . .: GOEDEREEDE (PILLAR 2)
REFERENCE MARK . . . .: ZIERIKZEE (LAMP '69)
INSTRUMENT . . . .: WILD T4 /1957
DATE . . . .: 4-6 1969.
OBSERVER . . . .: STEUR.

LATITUDE . . . .: 51 49 9.700
LONGITUDE. . . . .: -0 15 54.350
CHRONOMETER CORRECTION (UTC-T): 13 25 38.199
REFERENCE MOMENT . . . .: 5 6 21.801
CHRONOMETER RATE (SEC/HOUR). .: .008

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	335	15	8.950	141	42	45.570	48.2	5	10	44.650
	1	335	15	9.150	141	43	2.280	48.1	5	11	38.760
	2	155	15	16.300	321	43	56.280	46.2	5	14	13.520
	2	155	15	15.880	321	44	10.920	46.2	5	15	.470
2	1	342	45	7.980	149	16	38.190	47.9	5	23	9.520
	1	342	45	8.680	149	16	56.280	48.0	5	24	8.660
	2	162	45	16.210	329	17	44.480	47.0	5	26	28.850
	2	162	45	15.870	329	17	57.970	47.0	5	27	11.360
3	1	350	15	6.880	156	50	26.820	48.4	5	35	9.400
	1	350	15	7.000	156	50	59.850	48.2	5	36	46.890
	2	170	15	12.910	336	51	39.190	48.0	5	38	32.520
	2	170	15	13.440	336	51	57.620	47.9	5	39	26.010
4	1	5	15	8.700	172	5	28.380	48.6	6	19	20.220
	1	5	15	8.670	172	5	48.380	47.9	6	20	19.060
	2	185	15	14.310	352	6	32.220	47.8	6	22	4.460
	2	185	15	14.170	352	6	50.930	47.7	6	22	56.100
5	1	12	45	7.170	179	38	57.040	48.2	6	29	16.270
	1	12	45	7.500	179	39	20.390	48.2	6	30	21.190
	2	192	45	14.520	359	40	5.280	48.7	6	32	9.190
	2	192	45	14.220	359	40	34.220	48.8	6	33	29.850
6	1	357	45	7.380	164	44	49.320	47.4	6	45	35.850
	1	357	45	6.800	164	45	16.000	47.5	6	46	50.710
	2	177	45	14.620	344	46	17.090	48.3	6	49	20.340
	2	177	45	14.720	344	46	34.720	48.4	6	50	8.720

AZIMUTH BY POLARIS.

STATION. . . . .: GOEDEREEDE (PILLAR 2)
REFERENCE MARK . . . .: ZIERIKZEE (LAMP '69)
INSTRUMENT . . . .: WILD T4 /1957
DATE . . . .: 5-6 1969.
OBSERVER . . . .: STEUR.

LATITUDE . . . .: 51 49 9.700
LONGITUDE. . . . .: -0 15 54.350
CHRONOMETER CORRECTION (UTC-T): 16 19 .863
REFERENCE MOMENT . . . .: 2 11 59.131
CHRONOMETER RATE (SEC/HOUR). .: .008

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	20	15	12.030	186	56	54.900	47.6	2	56	54.220
	1	20	15	12.900	186	57	8.100	47.6	2	57	32.810
	2	200	15	17.430	6	57	42.000	50.5	2	59	9.500
	2	200	15	17.810	6	57	56.320	50.5	2	59	52.170
2	1	27	45	12.480	194	29	49.280	47.8	3	5	25.040
	1	27	45	12.720	194	30	2.280	47.7	3	6	6.130
	2	207	45	18.810	14	30	37.080	51.2	3	7	33.200
	2	207	45	18.180	14	30	49.380	51.1	3	8	13.650
3	1	35	15	12.750	202	2	22.920	47.6	3	12	56.750
	1	35	15	12.490	202	2	38.050	47.4	3	13	37.980
	2	215	15	17.780	22	3	8.320	51.6	3	14	55.890
	2	215	15	17.190	22	3	21.380	51.5	3	15	32.160
4	1	42	45	14.330	209	35	34.280	47.7	3	21	53.830
	1	42	45	14.600	209	35	47.830	47.5	3	22	31.860
	2	222	45	18.920	29	36	17.650	51.6	3	23	45.760
	2	222	45	19.080	29	36	30.780	51.8	3	24	25.310
5	1	50	15	13.800	217	10	28.890	47.4	3	35	41.710
	1	50	15	13.280	217	10	40.410	47.4	3	36	20.500
	2	230	15	19.320	37	11	10.420	52.2	3	37	28.840
	2	230	15	18.600	37	11	25.180	52.3	3	38	9.420
6	1	57	45	14.580	224	54	7.500	46.0	4	13	24.520
	1	57	45	15.220	224	54	25.870	45.9	4	14	14.510
	2	237	45	18.270	44	55	28.590	53.5	4	16	55.680
	2	237	45	18.920	44	55	48.210	53.6	4	17	47.120

STATION. . . . .: GOEDEREEDE (PILLAR 2)
REFERENCE MARK . . . .: ZIERIKZEE (LAMP '69)
INSTRUMENT . . . .: WILD T4 /1957
DATE . . . .: 10 AND 11-6 1969.
OBSERVER . . . .: STEUR.

LATITUDE . . . .: 51 49 9.700
LONGITUDE. . . . .: -0 15 54.350
CHRONOMETER CORRECTION (UTC-T): 15 45 8.370
REFERENCE MOMENT . . . .: 3 18 51.630
CHRONOMETER RATE (SEC/HOUR). .: .008

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	110	15	35.420	278	23	27.880	50.3	7	19	52.070
	1	110	15	35.960	278	23	40.790	50.2	7	20	37.490
	2	290	15	28.220	98	23	49.520	49.6	7	22	9.080
	2	290	15	28.720	98	24	1.680	49.5	7	22	30.450
2	1	117	45	34.570	285	55	59.130	49.6	7	28	36.940
	1	117	45	34.040	285	56	15.070	49.7	7	29	44.580
	2	297	45	25.600	105	56	35.600	50.4	7	31	49.380
	2	297	45	24.620	105	56	46.960	50.5	7	32	29.350
3	1	125	15	36.520	293	29	5.290	49.2	7	40	.740
	1	125	15	37.880	293	29	17.420	49.1	7	40	44.220
	2	305	15	28.250	113	29	18.980	50.6	7	42	.640
	2	305	15	28.980	113	29	29.800	50.6	7	42	42.190
4	1	132	45	28.520	301	7	46.190	50.0	8	15	45.070
	1	132	45	27.120	301	7	56.790	49.8	8	16	28.610
	2	312	45	16.970	121	8	5.820	50.6	8	18	3.160
	2	312	45	17.900	121	8	14.180	50.6	8	18	53.230
5	1	140	15	25.620	308	39	40.600	49.5	8	24	12.920
	1	140	15	26.700	308	39	49.030	49.6	8	24	50.330
	2	320	15	19.070	128	39	48.780	51.5	8	26	4.360
	2	320	15	19.670	128	39	56.720	51.3	8	26	48.300
6	1	147	45	20.590	316	11	10.520	49.0	8	31	45.080
	1	147	45	21.520	316	11	17.710	48.9	8	32	26.340
	2	327	45	12.990	136	11	17.260	51.8	8	33	35.800
	2	327	45	14.080	136	11	23.750	51.7	8	34	16.000

AZIMUTH BY POLARIS.

STATION. . . . .: ZIERIKZEE (PERM. MARK 12)
REFERENCE MARK . . . .: GOEDEREEDE (PILLAR 2)
INSTRUMENT . . . .: DKM3A NR. 134824
DATE . . . .: 21-8 1973.
OBSERVER . . . .: STEUR.

LATITUDE . . . .: 51 39 4.610
LONGITUDE. . . . .: -0 15 39.620
CHRONOMETER CORRECTION (UTC-T): 19 58 .730
REFERENCE MOMENT . . . .: 0 2 .000
CHRONOMETER RATE (SEC/HOUR). .: -.001

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	12	37	39.500	1	20	46.400	21.4	1	39	21.950
	1	12	37	38.900	1	20	46.100	21.4	1	40	34.140
	2	192	37	39.900	181	20	51.300	20.9	1	45	31.360
	2	192	37	39.400	181	20	54.800	21.0	1	46	50.360
2	1	72	37	9.400	61	19	44.100	18.5	2	30	12.290
	1	72	37	9.600	61	19	37.400	18.4	2	31	14.290
	2	252	37	8.500	241	19	22.400	20.4	2	34	36.490
	2	252	37	9.500	241	19	11.600	21.2	2	38	12.390
3	1	132	36	44.600	121	17	44.100	18.0	2	52	19.620
	1	132	36	45.000	121	17	39.800	18.0	2	53	22.430
	2	312	36	42.500	301	17	17.600	22.1	2	56	35.510
	2	312	36	41.400	301	17	11.600	22.2	2	57	48.500
4	1	192	36	35.300	181	14	36.700	17.8	3	19	56.040
	1	192	36	35.200	181	14	26.600	17.8	3	20	56.820
	2	12	36	34.800	1	14	8.400	22.4	3	23	9.980
	2	12	36	36.400	1	13	59.600	22.6	3	24	14.360
5	1	252	36	35.000	241	12	49.900	17.0	3	32	43.870
	1	252	36	35.800	241	12	24.900	17.0	3	35	45.030
	2	72	36	38.400	61	12	4.600	23.1	3	37	52.560
	2	72	36	37.500	61	11	50.500	23.3	3	39	15.620
6	1	312	36	41.700	301	11	4.000	17.0	3	44	54.980
	1	312	36	41.600	301	10	53.900	17.0	3	45	51.390
	2	132	36	46.000	121	10	26.000	23.6	3	48	41.680
	2	132	36	45.400	121	10	15.700	23.8	3	49	37.040

STATION. . . . .: ZIERIKZEE (PERM. MARK 12)
REFERENCE MARK . . . .: GOEDEREEDE (PILLAR 2)
INSTRUMENT . . . .: DKM3A NR. 134824
DATE . . . .: 22-8 1973.
OBSERVER . . . .: STEUR.

LATITUDE . . . .: 51 39 4.610
LONGITUDE. . . . .: -0 15 39.620
CHRONOMETER CORRECTION (UTC-T): 17 0 59.935
REFERENCE MOMENT . . . .: 0 10 .000
CHRONOMETER RATE (SEC/HOUR). .: -.001

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	27	38	9.600	16	1	58.600	19.3	2	9	43.810
	1	27	38	5.400	16	2	9.200	19.2	2	10	34.730
	2	207	38	3.600	196	2	32.400	22.0	2	12	32.430
	2	207	38	4.700	196	2	40.600	22.0	2	13	15.060
2	1	87	38	.200	76	7	24.200	18.5	2	35	10.780
	1	87	38	.800	76	7	34.200	18.5	2	36	2.870
	2	267	38	.400	256	7	48.600	21.2	2	37	32.150
	2	267	38	1.000	256	7	57.400	21.4	2	38	16.730
3	1	147	38	2.300	136	9	15.100	17.9	2	44	33.980
	1	147	38	1.900	136	9	22.000	17.9	2	45	19.660
	2	327	38	.600	316	9	37.000	21.2	2	47	5.910
	2	327	38	.400	316	9	44.800	21.4	2	47	45.540
4	1	207	37	56.600	196	10	43.300	17.2	2	53	18.590
	1	207	37	56.000	196	10	54.000	17.1	2	54	14.570
	2	27	37	53.700	16	11	7.900	21.2	2	55	58.410
	2	27	37	53.500	16	11	14.600	21.2	2	56	40.610
5	1	267	37	55.700	256	12	14.600	17.0	3	2	6.890
	1	267	37	55.900	256	12	22.400	17.0	3	2	55.240
	2	87	37	55.100	76	12	33.400	21.2	3	4	27.820
	2	87	37	56.100	76	12	40.300	21.3	3	5	10.710
6	1	327	37	56.200	316	13	55.900	17.0	3	12	58.950
	1	327	37	55.900	316	14	1.600	17.0	3	13	40.580
	2	147	37	54.700	136	14	9.100	21.0	3	14	57.940
	2	147	37	53.900	136	14	21.300	21.3	3	16	17.700

AZIMUTH BY POLARIS.

```
STATION. . . . . . . . . . . . .: ZIERIKZEE  (PERM. MARK 12)
REFERENCE MARK . . . . . . . . .: GOEDEREEDE  (PILLAR 2)
INSTRUMENT . . . . . . . . . . .: DKM3A NR. 134824
DATE . . . . . . . . . . . . . .: 23-8 1973.
OBSERVER . . . . . . . . . . . .: STEUR.

LATITUDE . . . . . . . . . . . .:  51  39   4.610
LONGITUDE. . . . . . . . . . . .:  -0  15  39.620
CHRONOMETER CORRECTION (UTC-T):    18  59  58.897
REFERENCE MOMENT . . . . . . . .:   0  13    .000
CHRONOMETER RATE (SEC/HOUR). .:    -.002
```

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	42	37	56.600	31	14	23.200	19.4	1	13	29.560
	1	42	37	55.500	31	14	33.400	19.4	1	14	30.210
	2	222	37	56.400	211	14	41.700	18.2	1	16	25.370
	2	222	37	55.400	211	14	50.200	18.6	1	17	20.150
2	1	102	37	55.900	91	15	50.400	19.0	1	24	18.080
	1	102	37	57.600	91	15	58.300	18.9	1	25	13.000
	2	282	37	53.900	271	16	6.000	18.2	1	27	8.930
	2	282	37	52.000	271	16	14.600	18.4	1	28	9.630
3	1	162	37	52.100	151	17	10.400	18.6	1	36	.600
	1	162	37	51.300	151	17	15.600	18.6	1	36	57.820
	2	342	37	46.800	331	17	22.600	18.4	1	38	55.150
	2	342	37	46.700	331	17	27.400	18.4	1	39	36.110
4	1	222	37	47.400	211	18	9.900	18.0	1	46	18.660
	1	222	37	46.000	211	18	15.700	18.0	1	47	3.540
	2	42	37	44.900	31	18	15.800	17.9	1	48	34.660
	2	42	37	44.600	31	18	23.300	18.0	1	49	37.560
5	1	282	37	44.400	271	20	23.900	19.1	2	18	28.580
	1	282	37	44.800	271	20	27.400	19.0	2	19	19.780
	2	102	37	40.400	91	20	26.400	18.3	2	20	50.550
	2	102	37	41.400	91	20	27.800	18.4	2	21	39.440
6	1	342	37	40.400	331	20	44.600	18.2	2	28	4.810
	1	342	37	40.200	331	20	45.600	18.2	2	28	47.870
	2	162	37	38.900	151	20	44.400	18.0	2	30	30.400
	2	162	37	39.000	151	20	43.800	18.1	2	31	12.760
7	1	57	37	39.500	46	20	25.600	18.0	3	16	6.590
	1	57	37	40.700	46	20	24.400	18.1	3	16	57.320
	2	237	37	38.100	226	20	11.600	18.0	3	18	45.570
	2	237	37	37.200	226	20	6.900	18.2	3	19	27.590
8	1	117	37	5.900	106	18	44.700	18.6	3	33	49.150
	1	117	37	6.400	106	18	41.900	18.5	3	34	31.700
	2	297	37	4.700	286	18	28.200	19.0	3	36	19.810
	2	297	37	4.500	286	18	26.100	19.1	3	37	2.420
9	1	177	37	.800	166	17	30.300	18.4	3	47	47.130
	1	177	37	1.600	166	17	26.600	18.4	3	48	29.910
	2	357	36	56.800	346	17	10.000	19.2	3	50	24.480
	2	357	36	56.300	346	17	5.400	19.3	3	51	6.960

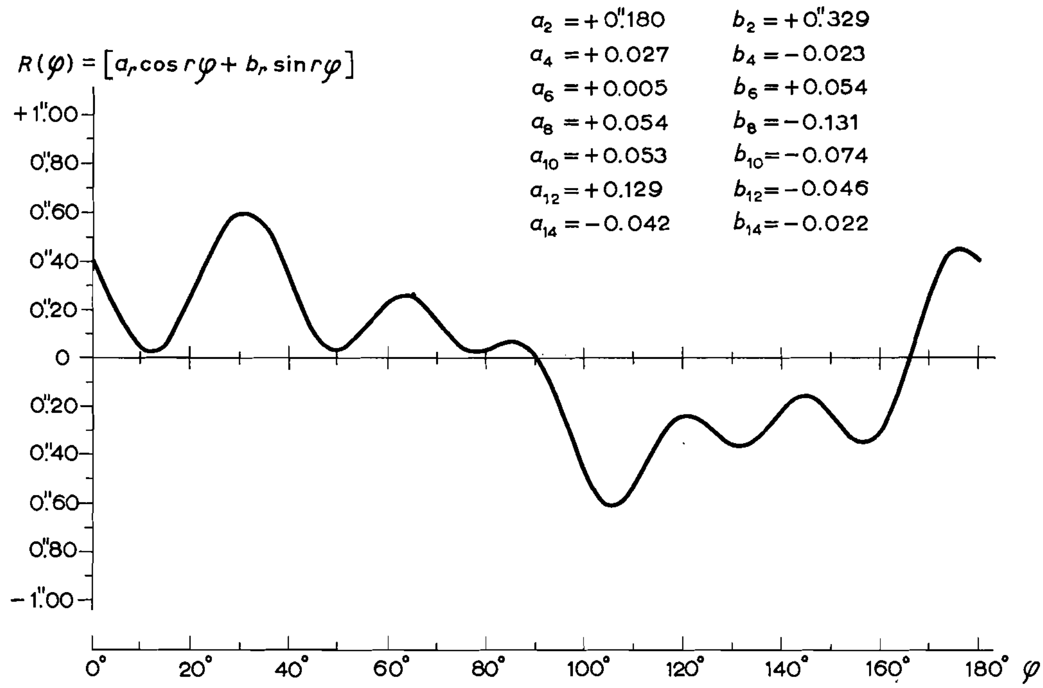
```
STATION. . . . . . . . . . . . .: ZIERIKZEE  (PERM. MARK 12)
REFERENCE MARK . . . . . . . . .: GOEDEREEDE  (PILLAR 2)
INSTRUMENT . . . . . . . . . . .: DKM3A NR. 134824
DATE . . . . . . . . . . . . . .: 28-8 1973.
OBSERVER . . . . . . . . . . . .: STEUR.

LATITUDE . . . . . . . . . . . .:  51  39   4.610
LONGITUDE. . . . . . . . . . . .:  -0  15  39.620
CHRONOMETER CORRECTION (UTC-T):    18  17  58.676
REFERENCE MOMENT . . . . . . . .:   0   5    .000
CHRONOMETER RATE (SEC/HOUR). .:    -.010
```

OBSERVATIONS:

SET	FACE	HOR.CIRCLE R.M.			HOR.CIRCLE STAR			LEVEL	CHRON. TIME		
1	1	192	37	13.400	181	4	16.200	19.6	0	43	50.279
	1	192	37	12.500	181	4	25.400	19.5	0	44	36.449
	2	12	37	10.200	1	5	13.500	20.2	0	48	45.697
	2	12	37	9.600	1	5	30.200	20.2	0	50	7.915
2	1	207	37	1.600	196	7	22.200	19.2	0	59	57.050
	1	207	37	2.600	196	7	32.300	19.3	1	0	45.010
	2	27	37	1.800	16	7	42.500	20.2	1	2	6.490
	2	27	37	.700	16	7	55.900	20.4	1	3	13.900
3	1	222	37	5.100	211	9	18.400	18.6	1	9	52.860
	1	222	37	5.200	211	9	25.900	18.6	1	10	41.480
	2	42	37	4.300	31	9	35.400	20.0	1	12	8.810
	2	42	37	2.900	31	9	44.400	20.0	1	13	2.190

Appendix IV

SYSTEMATIC ERRORS IN THE HORIZONTAL CIRCLE DIVISION OF THE THEODOLITE DKM 3A No. 134824



Appendix V Covariance matrix of the coordinates

			+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
LEEUWARDEN	Y	+1	+.2036	+.0183	+.2558	+.0149	-.0493	-.1096	-.0671	-.1114	-.1394	+.0036	-.1396	-.0215
	X	+2	+.0183	+.1697	+.0259	+.2140	+.0703	-.0707	+.0659	-.0862	-.0569	-.1074	-.0336	-.1188
AMELAND	Y	+3	+.2558	+.0259	+.3422	+.0225	-.0612	-.1345	-.0827	-.1366	-.1709	-.0009	-.1697	-.0308
	X	+4	+.0149	+.2140	+.0225	+.2868	+.0850	-.0873	+.0792	-.1057	-.0638	-.1290	-.0365	-.1415
GOEDEREEDE	Y	+5	-.0493	+.0703	-.0612	+.0850	+.1857	+.0153	+.1989	-.0199	-.0213	-.1588	+.0173	-.1763
	X	+6	-.1096	-.0707	-.1345	-.0873	+.0153	+.2575	+.0638	+.2786	+.2368	-.0144	+.2485	+.0351
ZIERIKZEE	Y	+7	-.0671	+.0659	-.0827	+.0792	+.1989	+.0638	+.2382	+.0339	+.0079	-.1843	+.0542	-.1981
	X	+8	-.1114	-.0862	-.1366	-.1057	-.0199	+.2786	+.0339	+.3171	+.2702	+.0059	+.2779	+.0647
UBACHSBERG	Y	+9	-.1394	-.0569	-.1709	-.0638	-.0213	+.2368	+.0079	+.2702	+.4978	+.0307	+.4903	+.1733
	X	+10	+.0036	-.1074	-.0009	-.1290	-.1588	-.0144	-.1843	+.0059	+.0307	+.3316	-.0700	+.3267
TONGEREN	Y	+11	-.1396	-.0336	-.1697	-.0365	+.0173	+.2485	+.0542	+.2779	+.4903	-.0700	+.5403	+.0791
	X	+12	-.0215	-.1188	-.0308	-.1415	-.1763	+.0351	-.1981	+.0647	+.1733	+.3267	+.0791	+.4212