pass five ϱ^3 cutting b and c. From this is evident that a, b and c are *fivefold right lines*.

With a right line m through O_k the scroll (α, β, γ) has thirteen points lying in O_k in common, so its image m' (right line through O_k) cuts ψ^{30} likewise in 13 points lying outside O_k. We conclude from this that the four points O are seventeenfold on ψ^{30}.

So the right lines $O_k O_l$ lie on this surface; that they are fourfold right lines can be shown in this manner.

As O_k and O_l are ninefold on (α, β, γ) the right line $O_k O_l$ is cut outside those points by 22—18=4 transversals of the curves α, β, γ; the images of these right lines are conics through O_k and O_l resting on $O_m O_n$, b, c and d and forming with $O_m O_n$ a ϱ^3 of the system.

The section of ψ^{30} with $O_1\, O_2\, O_3$ can consist outside the three fourfold right lines only of conics; these are easy to indicate. In the first place we can bring through O_1, O_2, O_3 a conic cutting b and c; it is completed to a ϱ^3 by each of the two right lines out of O_4 resting on the conic and on d. Then the sections of d and of the transversal with O_4 to b and c with O_1, O_2, O_3 determine a conic forming with the indicated transversal a ϱ^3. So we have in O_1, O_2, O_3 three double and three simple conics; with the three fourfold right lines they form a section of order 30.

On ψ^{30} lie therefore 4 seventeenfold points, 3 fivefold, 6 fourfold and 36 simple right lines, 12 double conics and 36 simple conics.

Astronomy. — *"Contributions to the determination of geographical positions on the West coast of Africa. III."* By C. SANDERS. (Communicated by E. F. VAN DE SANDE BAKHUYZEN).

(Communicated in the meeting of May 30, 1908).

I. Introduction.

After a stay in Europe during the winter 1902—1903 I returned to Portuguese West Africa and remained there until the autumn 1906 when I again went to Europe for some time.

During this period 1903—1906 I have once more tried to contribute to the determination of geographical positions in these parts as much as time and circumstances allowed. Circumstances, however, were often unfavourable to my observations, and hence the results obtained are less than I had desired and expected at first.

The results obtained may be ranged under three heads.

1. *New determinations at Chiloango.* In November and December

1903 I made here a new series of determinations of latitude by means of zenith distances in the meridian. But I did not succeed in securing new data with which to correct the determination of the longitude, and at last I have entirely given up this plan, until I should possess a telescope of the required dimensions for the observation of occultations of stars[1]), because the observations of the latter will certainly lead to a greater accuracy in the determination of the longitude than can be attained by means of lunar altitudes with my relatively small instrument.

2. *Determinations of astronomical coordinates at different stations in the Chiloango district.* On two journeys, one to N'Kutu on the upper course of the Chiloangoriver from 22 to 31 December 1903 and a longer journey through Mayombe[2]) in June 1904, I was able to make determinations of latitude and longitude. The reason why these could not be made oftener lies chiefly in the peculiar difficulties attached to the transportation of the instruments especially of the chronometers. The best way of transporting them is by water by means of a canoe, and even then one must constantly pay attention to avoid shocks caused by trees floating down the river. When the chronometers had to be transported by land, I used a hammock suspended from a long stick carried by two negroes; while mounting hills they tried to keep the stick as much horizontal as possible.

Another circumstance which makes it difficult to obtain accurate results is that these excursions can be undertaken only during the dry season, when the nightly sky is as a rule overcast, so that one must take recourse to observations of the sun, and lastly in many parts one meets with great difficulties in finding a proper dwelling place, because prosperous negro villages, which formerly existed, are almost entirely depopulated and turned into desert in consequence of the trypanosomosis, which has raged there.

On my journey in December 1903 the instruments were entirely transported by water, first by steamer to Mayili then by canoe to N'Kutu. At this latter station I secured determinations of latitude and longitude.

The journey through Mayombe in June 1904 also began by steaming up the Chiloango- (or Loango-) river to Mayili. We there arrived on June 2 and I made a time determination in order to control the longitude determined previously. We then travelled by land to

[1]) I received for some time past (1907) a telescope of Zeiss of 80 mm. aperture and 120 cm. focal length, with which I have already made some experiments.

[2]) The name of a part of the Chiloango district.

Chimbete (June 3) and then per canoe up the river to N'Kutu. The first transport by land, when the carriers were not yet accustomed to their uncommon task, unfortunately caused a perturbation in at least one of the two chronometers, which appeared from the comparisons between them.

Also at N'Kutu I made a time determination on June 5, in order to obtain another result for the longitude of that place. On June 6 we continued our journey by land often along very difficult roads through woods and over hills and some times across small streams. We first went to the north east as far as N'Vyellele, a village 28,5 kilometers north east of N'Kutu (June 7), and then we travelled to the west during three days until June 10, when we reached Buku-Zan, a village on the Luali, a tributary river of the Loango.

On June 13 and 14 we made an excursion from Buku-Zan to the north to M'Pene Kakata, but the rest of the time until June 16 I stayed in the former place and availed myself of this opportunity to determine its longitude and latitude.

On June 16 we returned from Buku-Zan to N'Kutu. This time we went directly to the south east, and after we had covered a distance of 38 kilometers we arrived at N'Kutu on June 17. Thence we returned by the way we had come via Chimbete and Mayili to Chiloango (18—23 June). In the mean time I secured determinations of latitude and longitude at Chimbete.

3. *Connection of a great number of secondary points with the astronomically determined stations, by means of compass directions and distances.* It was my intention to form by means of my astronomical determinations a net of primary points with which I might connect a great number of intermediate points whose relative positions I had determined on many journeys by means of compass directions and distances, in order thus to reach also for the latter a satisfactory accuracy. In this I have partly succeeded, but for the southern part of the district it is still necessary to make the astronomical determination of one and if possible 2 stations on the Lukula river, Chipondi and perhaps Pouro, the more so as the preliminary result of my secondary determination of the station Lemba on this river differs much from that which Mr. CABRA had obtained some years ago, when he determined the demarcation between the Freestate and Portuguese Congo.

I shall try to fill up this gap. But the difficulties are especially great in these parts, as the trypanosomosis has badly raged here of late. At any rate it will be desirable to put off till later the communication of my secondary determinations.

CORRECTIONS AND RATES OF THE CHRONOMETERS.

Date	M. T.	Temp. C.	Chron. Hewitt Corr	D. Rate	D. Rate 20° C.	Chron. Hohwü Corr.	D. Rate
	h		m s	s	s	m s	s
1903 May 15	8 12		+47 59 03			+46 55 03	
" 20	8 15	24.5	58.38	—0 13	—1 25	56 38	+0 27
" 25	8 46	24 0	57 24	—0 23	—1.23	57 24	+0.17
June 20	8.18	22.0	38.13	—0 74	—1 24	48.13	—0.35
" 27	8.10	19 6	31.41	—0 96	—0.86	45.41	—0 39
July 3	8.32	19.6	26 06	—0 89	—0.79	40.06	—0 89
" 10	8.25	19 7	18 71	—1.05	—0.97	32.71	—1.05
" 17	8 10	20 1	11.17	—1 08	—1 10	27.57	—0.73
" 25	8.50	19 1	1 98	—1.15	—0.93	20.48	—0.89
Aug. 4	8.15	9 7	+46 51.06	—1.09	—1.01	15 06	—0.54
" 24	8 22	21 0	41.03	—0.50	—0.52	8.53	—0 33
Oct. 12	8.45	24.4	41.88	+0.02	—1.08	13.38	+0.10
" 19	8.10	25 6	44 45	+0.37	—1.03	17.95	+0.65
Nov. 5	7.93	25.5	54 35	+0 58	—0.80	21 85	+0.23
" 16	8.53	26.0	+47 2 31	+0 72	—0.78	22.81	+0 09
" 20	7 98	25.6	4 32	+0 50	—0 90	23.92	+0.28
Dec. 20	8.05	25.3	17.97	+0.46	—0 86	48.97	+0.83
1904 Jan. 3	8.04		28.08	+0 72		52 08	+0.22
" 6	8.43	25.3	28 70	+0 21	—1.11	53.20	+0.37
" 17	7 97	25.7	35 56	+0.62	—0 80	+47 0.56	+0.67
" 22	8 20	25 4	37.35	+0.36	—0.99	5.35	+0 96
" 29	8 44	25 2	40.79	+0 49	—0.81	10 79	+0.78
Febr. 9	8 40	25.3	45 93	+0.47	—0.85	19.43	+0.78
" 20	8 05	25.8	55 41	+0.86	—0 59	21 41	+0 18
March 4	8 23	25.8	+48 8 69	+1.02	—0.43	30.69	+0 71
" 31	8 08	25.7	38 47	+1.10	—0.32	43.47	+0.47
May 12	8.08	25.5	+49 13.51	+0.83	—0.55	+48 8.01	+0.58
" 23	7.80	24 5	14.83	+0.12	—1.00	18.33	+0.94
" 30	8.37	24.4	15.66	+0 11	—0.99	26.66	+1.18
June 24	7.70		22.83	+0 29		47.33	+0.83
Aug. 1	8.30	20.9	17.42	—0.14	—0.36	+49 8.92	+0.57
Sept. 30	7.90	21.2	+48 58.86	—0 31	—0.61	20.86	+0.20
Oct. 14	8 24	23.8	+49 1.48	+0 19	—0 79	25.98	+0.37

Date			M. T.	Temp. C.	Chron. Hewitt Corr	Chron. Hewitt D. Rate	Chron. Hewitt D. Rate 20° C.	Chron. Hohwü Corr	Chron. Hohwü D. Rate
			h		m s	s	s	m s	s
1904	Oct.	24	8 30	24.3	+49 5 35	+0 39	—0 69	+49 33 85	+0 79
	Nov.	5	8.25	24.6	10 03	+0.39	—0.76	42.03	+0 68
	„	10	8.25	25 1	11 93	+0.38	—0 90	44 93	+0.58
	„	18	8.07	25.1	15.25	+0 42	—0.86	51.75	+0.85
	„	29	7.99	25 5	19.97	+0.43	—0 95	+50 3.97	+1.11
	Dec.	9	8.10	25.1	26.46	+0.65	—0 63	11.96	+0.80
	„	19	8.32	25 0	28.54	+0.21	—1 03	22.04	+1 11
1905	Jan.	2	8.12	24 6	31.26	+0 19	—0.96	34.26	+0 87
	„	14	8.10	25.7	36 40	+0 43	—1 01	46 40	+1.01
	„	21	9.24	25 6	38.64	+0 32	—1.08	52.14	+0.82
	Febr.	12	8 43	25.9	49 17	+0 48	—0.99	+51 2.17	+0.46
	„	25	8.54	26.2	57.37	+0 63	—0.91	7.87	+0 44
	March	5	8.03	26.4	+50 2.23	+0.61	—1.00	6 73	—0.14
	„	25	7 94	26.6	16 72	+0.72	—0.92	10.72	+0.20
	Apr.	21	8.22	26.6	36.74	+0.74	—0 90	1 24	—0.35
	June	27	8.20	24.1	50 70	+0.21	—0.82	+50 57.70	—0.05
	Sept.	1	8 66	21.0	29 38	—0.32	—0.57	29.38	—0.43
	„	3	8.64	21.6	29.36	—0.01	—0 65	28.86	—0 26
	„	7	8.35	22.6	28.35	—0.25	—0 90	24.35	—1.13
	Oct.	19	8.05	24.0	33.86	+0.13	—0.86	1 86	—0.54
	„	31	7.99	25.2	37.20	+0 28	—1.03	+49 53.70	—0.68
	Nov.	4	8.32	25.1	40.33	+0.78	—0.50	52.53	— 0.29
	„	22	8.39	26.1	51.46	+0 62	—0.91	39.96	—0 70
	Dec.	6	8 18	26.3	+51 2 09	+0 76	—0.82	31.09	—0.63
	„	16	8.20	25.6	9.58	+0.75	—0.65	23.58	—0.75
1906	Jan.	8	8.24	26.2	26 52	+0.74	—0.81	9.02	—0.63
	Febr.	24	8 45	26.3	+52 8.84	+0.90	—0.68	+48 11.34	—1.23
	March	11	8 37	27.3	26.09	+1.15	—0.67	+47 58.09	—0.88
	„	21	8.11	26.7	33.93	+0.78	—0.90	48.43	—0.97
	Apr.	3	7.90	26.6	43 32	+0.72	—0.92	35.62	—0.99
	May	6	8.45	25.8	58.36	+0.46	—1.00	0.96	—1.05
	June	1	8.14	24.2	52.20	—0.24	—1.28	+46 29.84	—1 21
	„	18	8.09	22.7	39.07	—0.77	—1.43	1.57	—1.66
	July	19	8.52	20.8	8.52	—0.98	—1.22	+45 9.52	—1.68

II. *Time determinations at Chiloango. Corrections and rates of the chronometers.*

In 1903 before I left for Africa I added to my chronometer of HEWITT another of HOHWÜ. During my stay at Chiloango from May 1903 to July 1906 I have regularly controlled both by making at proper intervals time determinations in the same way as before by altitudes determined with my altazimuth. Moreover I have daily intercompared the two chronometers.

With regard to the time determinations themselves I need only add to what has been said before:

1. that new determinations of the value of a level-part yielded 5″.4, exactly as before;

2. that the flexure and the division errors of the instrument were regularly taken into account according to the formulae in "*Contributions* I".

Here follow the results for the corrections and rates of the chronometers. The rates, and also the temperatures added to them, refer to the interval between the date on one line above and that on the line itself. The temperatures for the periods of the two journeys are wanting. To the "Rates HEWITT 20° C." I shall refer later.

I have first investigated the rates of the chronometers with regard to the temperature and to this end I have formed mean rates for periods of about 2 months, in each summer and winter.

Period	Temp. C.	Chron. Hewitt.		Chron. Hohwü.	
1903 June 20—Aug. 4	19.63	$-1^{s}.05$		$-0^{s}.73$	
Nov. 5—March 31 [1]	25.58		$+0^{s}.71$		$+0^{s}.59$
1904 June 24—Sept. 30	21.03	− 0.24		+ 0.34	
1905 Febr. 12—April 21	26.42		+ 0.70		− 0.01
June 27—Sept. 1	20.95	− 0.32		− 0.43	
1906 Jan. 8—April 3	26.83		+ 0.90		− 1.10
June 18—July 19	20.82	− 0.98		− 1.68	

For the chronometer of HEWITT I found a very distinct influence of the temperature and, in so far as I could find then, no variation with time.

[1]) I have excluded the period of my journey from Dec. 20 to Jan. 3.

For the simple means of the 4 winter and the 3 summer rates and of the temperatures belonging to them I find:

26°.28	+ 0s.77
20 .61	— 0 .65

hence: Variation per degree + 0s.25 [1])

By means of this coefficient of temperature I have reduced all the rates to 20°; these reduced rates are given in the table above in the column: D. Rate 20° C. The simple mean value of these reduced rates is — 0s.87, from which the real mean reduced rate — 0s.83 differs only little. By forming the differences between the reduced rates and their mean I found for the mean error of a daily rate, disregarding the different lengths of the intervals between the time determinations:

M.E. ± 0s.225

a very satisfactory result, especially in consideration of the fact that for the whole period of more than 3 years we have adopted a constant rate depending on the temperature only.

For the chronometer of Hohwü the results are somewhat less favourable. One sees at a glance a distinct variation with time which from 1904 seems to continue in the same sense.

In order to derive the coefficient of temperature I have compared each summer rate with the mean of the two neighbouring winter rates and thus found:

Rate summer—winter + 0s.78
+ 0 .03
— 0 .05

A regular influence of the temperature does not appear from these data and the greater value of the first difference must be ascribed to an irregular variation in the beginning. Therefore I have accepted for the coefficient of temperature 0s.00 and, in order to investigate the variation which is independent of the temperature I have formed mean rates for periods of about three months. They follow here together with the corresponding values for the chronometer of Hewitt reduced to 20°.

1) It was impossible to determine also a quadratic term on account of the small differences of temperature. For the years 1901—'02 the temperature coefficient was found to be + 0s.18.

DAILY RATES FROM PERIODS OF THREE MONTHS.

	D. Rate Hewitt red. to 20°	D. Rate Hohwü
	s	s
1903 May 15—Aug. 4	— 1.08	— 0.49
Aug. 4—Nov. 5	— 0.90	+ 0.07
Nov. 5—Jan. 29	— 0.86	+ 0.65
1904 Jan. 29—May 12	— 0.51	+ 0.55
May 12—Aug. 1	— 0.56	+ 0.72
Aug. 1—Nov. 5	— 0.66	+ 0.34
Nov. 5—Jan. 21	— 0.93	+ 0.91
905 Jan. 21—Apr. 21	— 0.94	+ 0.10
Apr. 21—June 27	— 0 82	— 0.05
June 27—Nov. 4	— 0.72	— 0.50
Nov. 4—Febr. 24	— 0.76	— 0.90
1906 Febr. 24—May 6	— 0.90	— 0.99
May 6—July 19	— 1.29	— 1.51

The values of this table also show the greater regularity of the chronometer of Hewitt for which only the last rate 'shows a greater deviation. The rate of that of Hohwü seems tolerably constant during the period 1903 Nov. 5—1905 Jan. 21 for which the mean rate amounts to $+ 0^s.61$.

From the differences between the single rates in this period and their mean we find, again disregarding the lengths of the intervals:

M.E. Daily rate Hohwü $\pm\ 0^s,30$

still greater than for Hewitt. But on the other hand the large coefficient of temperature of the latter is a disadvantage for periods for which the temperature is not accurately known.

III. New determination of the latitude of Chiloango.

In the months of November and December 1903 I made a new determination of the latitude of Chiloango, again by altitudes observed with my universal instrument, with the only difference that a much greater number of stars was observed, but with only one pointing for each of them at the moment of transit over the meridian. The observations were arranged so that 2 northern and 2 southern stars

1903 DECEMBER 7

Adopted runcorrection for 10′ —0′.66
„ zenith point 239°59′47″.32
Temperature and barometer for 1st star 25.3 759.4
4th „ 24.9 759.5
6th „ 24.6 759.6
12th „ 24.0 759.8

Star		Readings Micr. A	Micr. B	Level corr.	Zenithdist.	Refr.	Lat.
							—5°11′
α Sculptoris	R	264°40′ 15″	39′ 51″	— 3″.89	24°40′ 12″.12	25″.37	68″.01
		15	51				
β Phoenicis	L	197 58 49	58 24	— 2.97	42 1 14.53	49.73	69.94
		48	23				
β Andromedae	R	280 18 7	17 42	0.00	40 18 8.23	46.82	64.95
		7	47				
δ Cassiopeiae	L	175 5 24	5 5	+ 2.59	64 54 31.00	1′ 57.47	65.87
		23	3				
γ Phoenicis	R	278 35 57	35 33	+ 1.08	38 35 58.96	44.13	67.91
		58	33				
α Eridani	L	187 29 33	29 15	— 2.43	52 30 26.79	1 12.04	66.67
		34	11				
φ Persei	R	295 23 10	22 57	— 3.78	55 23 14.28	1 20.03	66.71
		12	56				
ε Cassiopeiae	L	171 38 9	37 56	+ 0.54	68 21 44.73	2 18.50	62.93
		9	55				
α Hydri	R	296 49 0	48 39	+ 0.81	56 49 1.24	1 24.44	65.02
		48 58	35				
γ Andromedae	L	192 56 47	56 23	— 4.86	47 3 18.03	59.55	62.48
		45	22				
α Arietis	R	268 12 3	11 38	— 1.62	28 12 2.27	29.75	59.02
		5	38				
φ Eridani	L	193 15 24	14 55	+ 2.70	46 44 35.38	58.91	64.91
		22	56				

Date	Star		Zenith dist.	Latitude			
				N. R	N. L.	S. R.	S L.
1903				— 5°11′			
November 28	ζ Toucani	R	S 60°			57″42	
Zenithp. 180°	α Phoenicis	L	S 38				58″21
	α Cassiop.	R	N 61	66″43			
	γ Cassiop.	L	N 65		71″99		
	α Sculptoris	R	S 25			49.73	
	β Phoenicis	L	S 42				59.27
	β Androm.	R	N 40	65.53			
	υ Piscium	L	N 32		71.42		
	δ Cassiop.	R	N 65	67.73			
	Mean			**66 56**	**71 70**	**53 58**	**58 74**
December 2	γ Cassiop	L	N 65		67.85		
Zenithp. 210°	α Sculptoris	R	S 25			57.91	
	β Androm.	R	N 40	67.85			
	Mean			**67 85**	**67.85**	**57 91**	
December 6	α Sculptoris	R	S 25			60.98	
Zenithp. 210°	β Phoenicis	L	S 42				64 35
	β Androm.	R	N 40	69.94			
	δ Cassiop.	L	N 65		69.59		
	γ Phoenicis	R	S 39			63 53	
	α Eridani	L	S 53				59 45
	Mean			**69 94**	**69 59**	**62.26**	**61.90**
December 7	α Sculptoris	R	S 25			68.01	
Zenithp. 240°	β Phoenicis	L	S 42				69.94
	β Androm	R	N 40	64.95			
	δ Cassiop.	L	N 65		65.87		
	γ Phoenicis	R	S 39			67 91	
	α Eridani	L	S 53				66.67
	φ Persei	R	N 55	66 71			
	ε Cassiop.	L	N 68		62 93		

Date	Star		Zenith dist	Latitude			
				N. R	N. L.	S. R.	S. L.
					— 5° 11′		
Dec. 7 cont.	α Hydri	R	S 57°			65″02	
	γ Androm.	L	N 47		62″48		
	α Arietis	R	N 28	59″02			
	φ Eridani	L	S 47				64″91
	Mean			**63.56**	**63.76**	**66.98**	**67.17**
December 10	δ Cassiop.	L	N 65		63 11		
Zenithp. 270°	γ Phoenicis	R	S 39			68 08	
	α Eridani	L	S 53				69.66
	φ Persei	R	N 55	61.18			
	ε Cassiop.	L	N 68		64.79		
	α Hydri	R	S 57			68 58	
	β Trianguli	R	N 40	62.54			
	φ Eridani	L	S 47				71.22
	Mean			**61.86**	**63.95**	**68.33**	**70.44**
December 14	γ Phoenicis	R	S 39			62 22	
Zenithp. 300	α Eridani	L	S 53				62 88
	β Arietis	R	N 26	58.41			
	α Hydri	R	S 57			65.99	
	γ Androm.	L	N 47		59.56		
	β Trianguli	R	N 40	64 07			
	φ Eridani	L	S 47				61.99
	δ Hydri	R	S 64			64 13	
	Mean			**61.24**	**59.56**	**64.11**	**62.44**
December 15	δ Cassiop.	L	N 65		68.96		
Zenithp. 330	γ Phoenicis	R	S 39			64.05	
	α Eridani	L	S 53				59.03
	φ Persei	R	N 55	72.49			
	ε Cassiop.	L	N 68		68.16		
	α Hydri	R	S 57			57.46	
	γ Androm	R	N 47	67.16			
	β Trianguli	L	N 40		68.18		
	φ Eridani	L	S 47				59.67
	Mean			**69.82**	**68.43**	**60.76**	**59.35**

were observed alternately, and of each of these pairs the one in the position circle to the right, the other in the position circle to the left.

The readings were always made with each of the two microscopes both on the preceding and on the following division. The corrections for run and for the level reading were applied exactly as before (comp. *Contrib.* I. p. 280), the refraction was derived from the tables of BESSEL and the declinations of the stars were taken as before from the *Nautical Almanac,* i. e. from the catalogue of NEWCOMB. Only now and then I have also observed stars from the *Berliner Jahrbuch,* namely υ Piscium, σ Cassiopeiae and φ Persei. To reduce them to NEWCOMB I have applied to them the following corrections: $-0''.1$, $-0''.8$ and $+0''.7$, according to data communicated to me by Dr. E. F. v. D. SANDE BAKHUYZEN.

The reading for the zenith was assumed to be constant for each night and determined so as to make all the stars agree inter se as well as possible. By the regular alternation of the positions of the instrument an error in the adopted zenith point was eliminated almost entirely.

The observations were made in 6 positions of the circle, each differing from the next by 30°.

As an example I will first give the observations of one night in full.

I now proceed to give for all the observations the resulting values for the latitude in 4 columns: for the north stars circle right and left and for the south stars circle right and left. To these I add the approximate zenith distances of the stars.

The observations at zenith point 210° are distributed over two nights, Dec. 2 and Dec. 6. Because it is not permissible to consider the zenith point for the two as exactly equal, it seemed better to exclude from the observations of Dec. 2 the only southern star obtained. For the rest no observations are excluded, not even the few which deviated rather much.

For each position of the circle I have combined the results for the two positions of the instrument, but I kept apart those from the northern and from the southern stars and so I obtained: (see p. 100)

To the results from the northern and the southern stars I have added their differences and their means. In so far as we may assume that the north and the south stars had in the mean the same zenith distance, the former represent the corrections to the measured arcs of $2z$ for errors of division $+$ double the correction to the measured z for flexure (comp. *Contrib.* 1 p. 285), while on the

7*

Zenithpoint	North stars	South stars	N—S	$\frac{N+S}{2}$
	— 5° 11′			— 5° 12′
180°	69″13	56″16	— 12″97	2″64
210	68.81	62.08	— 6.73	5.44
240	63.66	67.08	+ 3.42	5.37
270	62.90	69.38	+ 6.48	6.14
300	60.40	63.28	+ 2.88	1.84
330	69.12	60.06	— 9.06	4.59
Mean	**65.67**	**63.01**	— 2.66	**4.34**

same supposition the means from the north and the south stars are free from these two errors.

To derive the errors of division and of flexure we obtain, the mean zenith distance amounting to 49°, with the same notations as before:

$$a' = \quad 2a \sin 98° = -10.''16$$
$$b' = -2b \sin 98° = +\ 0.83$$
$$c' = \quad 2c \sin 49° = -\ 2.66$$

whence, if a stands again for the circle reading:

Correction for division errors to the circle reading $-5.''13 \sin 2a - 0.''41 \cos 2a$
$= +5.''15 \sin (2a - 175.°4)$

Correction for flexure to the zenith distance $-1.''76 \sin z.$

The mean of the values in the last column is:

$$\varphi = -5°12'4''.34.$$

The formula for the correction for division errors agrees very well with that derived from the observations of 1900—01, which is of importance for the correction of my other observations of zenith distances. For the coefficient of the flexure I had formerly found $-0.''60$; the difference may still be ascribed to accidental causes.

Finally I give here the 12 separate results for the latitude, each corrected for division errors and flexure. (see p. 101).

Their mean value must of course be equal to that of the uncorrected results. From the comparison of the former with their mean we derive for the mean error of the final result ± 0.″57. Hence this is:

$$\boldsymbol{\varphi = -5°12'4''.34 \pm 0'',57.}$$

	North stars	South stars
	— 5° 12′	
180°	2″72	2″57
210	5.30	5.59
240	5.23	5.51
270	6.65	5.63
300	1.25	2.43
330	4.89	4.29

This result may be combined with that of 1900—01. For the latter I adopt the first value of *Contrib.* I p. (284), but I estimate its mean error to be not less than that which I have now found. Thus:

Latitude of the pier of observation.

1900—01	— 5° 12′ 4″.01 ± 0″.6
1903	4 .34 ± 0 .6
Together	**— 5° 12′ 4″.2 ± 0″.4**

I think that the agreement is quite satisfactory.

IV. *Determinations of the longitude and the latitude of N'Kutu, Mayili, Buku-Zan and Chimbete.*

1. *Journey of* 1903 *December* 22—31. *Observations at N'Kutu.* During this journey the chronometers were transported all the way by water, hence extraordinary perturbations are not to be feared. But the temperature was certainly higher than at the same time at Chiloango; it amounted at least to 26° and may have been between 26° and 30°. A comparison of the rate of Hewitt from Dec. 20 to Jan. 3 with the mean reduced rate for those months would yield a temperature of 26°.4, which is of course an uncertain estimation. Although there is no reason to expect any difference in temperature between the journey to N'Kutu and the journey back, yet the uncertainty about this affords a disadvantage for Hewitt and therefore, for the determination of the longitude, I have finally given equal weights to the two chronometers.

The computation of the time and the latitude at a place of which the geographical position is unknown had of course to be made in successive approximations. Here I shall give only the final results, The observations were made in the factory of the firm Hatton and Cookson.

Determination of the longitude. A time determination of 26 Dec. by means of 4 observations of β Orionis in both positions of the instrument, each time over 7 horizontal threads, yielded the following corrections of the chronometers to the mean time of N'Kutu. Together with these I give the corrections to the mean time of Chiloango derived by simple interpolation — the best thing to be done — between the time determinations of Dec. 20 and Jan. 3, and finally the resulting difference of longitude.

December 26.296 (M. T. Chiloango).

	Hohwü	Hewitt
Correction to M. T. N'Kutu	$+ 48^m 48^s.85$	$+ 49^m 22^s.35$
,, ,, ,, Chiloango	46 50 .29	47 22 .27
Difference of longitude	— 1 58 .56	— 1 60 .08

Adopting the simple mean of the two results, we find for the longitude of N'Kutu relatively to Chiloango

$$-1^m\ 59^s.32.$$

Determination of the latitude. On December 29 I secured a determination of the latitude by 3 pairs of observed zenith distances, i.e. three observations in each position of the instrument, of β Andromedae ($z = 40°$ North) and by 2 pairs of α Eridani ($z = 53°$ South).

The results were:

β Andromedae	1st pair	—4°57′ 9″.90
	2d ,,	11.06
	3d ,,	11.24
	Mean	10.73
	Corrected	—4°57′ 5″.74
α Eridani	1st pair	—4°56′57″.69
	2nd ,,	59.81
	Mean	58.75
	Corrected	—4°57′ 3″.72

Hence the mean result for the latitude is:

— 4° 57′ 4″.7

2. *Journey of* 1904 *June* 2—23. *Corrections of the chronometers.*

As this journey was made almost entirely by land the circumstances were much less favourable for the regularity of the chronometers, in spite of all precautions taken. The intercomparisons, which were made at least once every day, clearly show small irregularities now and then and once on June 3, when the carriers were not yet accustomed to their task, as I have said before, a serious perturbation occurred.

The instruments were almost always carried in the shadow of the woods and only a few times they can have been exposed to the sunbeams. We must assume, however, that they were subject to the general fall of temperature which occurs in these parts in June, and thence follows that we may not accept a constant rate for the chronometer of HEWITT.

From my regular thermometer readings in 1903 and 1905 I derive for the mean fall of temperature during June 2°.18, i. e. on an average per day 0°.073; this would cause a variation of rate for HEWITT of — $0^s.018$ per day. On this supposition and starting from the time determinations at Chiloango of May 30 and June 24; the daily rate would have been at the beginning (May 30—31) + $0^s.50$ and at the end (June 23—24) + $0^s.08$.

As the temperature coefficient of HOHWÜ may be considered zero, we may gather some evidence on this point from the relative rates during the journey. Beginning after the perturbation on June 3, I find the following differences between the two chronometers, each being the mean result from at least three comparisons, and derive from them the relative rates subjoined.

	Hohwü — Hewitt	
June 5	+ $49.^s00$	
		— $0.^s37$
10	47.17	
		— 0.53
15	44.50	
		— 1.07
20	39.17	
		— 0.92
24	35.50	

As the mean rate of HOHWÜ was about + $0.^s9$, these values agree fairly well with the assumed variable rate for HEWITT, which I therefore adopt as the most probable. For the middle of the period, June 12, the chronometer correction derived by means of the latter rates differs from that which would follow from the constant rate + $0.^s29$ by $1.^s36$.

A great difficulty is caused by the perturbation on June 3, when the difference between the chronometers seems to have varied abruptly

3 secs. It was probable that this must be attributed to the chronòmeter HOHWÜ, which supposition seems confirmed by the time determination at N'Kutu of June 5 if we reduce it to Chiloango with the difference of longitude determined in Dec. 1903, but it is undoubtable that we have here a source of uncertainty for the following determinations of longitude. I already remark here that I have finally accepted no jump in HEWITT and one of 2 seconds in HOHWÜ. For the daily rate of the latter we then must accept + 0ˢ.91 instead of + 0ˢ.83. In addition I remark that also for the determinations in 1904 I have assigned equal weights to the two chronometers.

3. *Determinations of longitude in* 1904.

Mayili. On June 2 I here secured a time determination by means of Sirius west, and of α Bootis east of the meridian. The results obtained from the two, corrected for division errors and flexure, differ inter se by 0ˢ.37.

Here follow the mean results, to which I have added the corrections to the mean time of Chiloango derived by means of the adopted rates (+ 0ˢ.91 for HOHWÜ and a variable rate for HEWITT) and the difference of longitude derived thence.

June 2 6^h5 M.T. Chiloango

	Hohwü	Hewitt
Correction to M.T. Mayili	+ $49^m50^s.89$	+ $50^m36^s.39$
„ „ „ Chiloango	+ 48 29 .33	+ 49 17 .08
Difference of longitude	— 1 21 .56	— 1 19 .31
	Mean	— $1^m20^s.44$

In 1902 I had found — $1^m21^s.3$.

If we had derived the correction of HOHWÜ with a rate of +0ˢ.83, the difference of longitude according to this chronometer would have been — $1^m21^s.80$, while HEWITT with an assumed constant rate would have yielded — $1^m19^s,89$.

N'Kutu. Here I was obliged to have recourse to the sun for determination of time and on June 5 I obtained the following results from 4 observations of the two limbs in the two positions of the instrument. I now begin by deriving the correction of HOHWÜ to the M. T. of Chiloango, without accepting a jump, and therefore with the rate + 0ˢ.83.

June 5 3h.1 M.T.

	Hohwü	Hewitt
Correction to M.T. N'Kutu	$+ 50^m28^s.54$	$+ 51^m17^s.54$
„ „ „ Chiloango	+ 48 31 .45	+ 49 18 .30
Difference of longitude	— 1 57 .09	— 1 59 .24

while the result of Dec. 1903 was $-1^m59^s.32$. From this it would appear that on June 3 a perturbation occurred in Hohwü and not in Hewitt and that the jump in the former amounts to about 2 secs., which agrees sufficiently with the observed abrupt variation in the difference between the two.

For a more accurate investigation of the perturbation I have tried to avail myself of the time determination of June 2 at Mayili, after having reduced it to Chiloango by means of the difference of longitude determined in 1902, but this has not thrown more light on the subject. Everything considered I have finally accepted as the effect of the perturbation: a jump of 2 seconds in Hohwü.

As to the longitude of N'Kutu itself, it will be best to use for it only the determination of Dec. 1903, although the new determination by Hewitt perfectly agrees with it.

Buku-Zan. My observations were made in the factory of the firm Hatton and Cookson. For a time determination I could obtain only 3 pointings at the sun's limbs on June 14. To their results I have added the corrections to M. T. Chiloango according to the adopted computation (i. e. with a jump in Hohwü and a variable rate of Hewitt) and also the difference of longitude derived from them.

June 14 4h0 M.T.

	Hohwü	Hewitt
Correction to M.T. Buku-Zan	$+ 50^m13^s43$	$+ 50^m57^s93$
„ „ „ Chiloango	+ 48 38.12	+ 49 21.22
Difference of longitude	— 1 35.31	— 1 36.71

Mean -1^m36^s01

Computed with constant rates and without an assumed jump the results would have been -1^m34^s51 and -1^m38^s02, hence in less good harmony.

Chimbete. Also here (factory of Hatton and Cookson) I could observe only the sun for a time determination, but I secured at least a complete set of 4 observations of both limbs in both positions; the two pairs computed separately differ by $0.^s83$.

The results were the following; to these I have added the corrections to M. T. Chiloango according to the adopted computations, and the difference of longitude derived by means of them.

June 21 3^h6 M. T.

	Hohwü	Hewitt
Correction to M. T. Chimbete	$+ 50^m37^s73$	$+ 51^m15^s73$
,, ,, ,, Chiloango	$+ 48$ 44.46	$+ 49$ 22.52
Difference of longitude	— 1 53.27	— 1 53.21
Mean	$-1^m 53^s24$	

whereas if computed with constant rates without an assumed jump I would have got -1^m53^s03 and -1^m53^s81.

Thus the results following from the two computations differ much less than for the other places.

4. *Determinations of latitude in* 1904.

Buku-Zan. For a determination of the latitude I could observe only on June 15 one star in the south, β Centauri. Of this star I obtained 8 pointings distributed equally over the two positions.

The results were:

1st pair	$\varphi = -4° 46' 4''46$
2nd ,,	5.51
3rd ,,	8.54
4th ,,	6.51
Mean	6.26

and after correction for division error and flexure

$$\varphi = -4° 46' 11''.1.$$

Chimbete. I only succeeded on June 20 in securing 10 pointings on α Crucis, distributed equally over the two positions, with the following results.

1st pair	$\varphi = -5° 1' 18''.40$
2nd ,,	18.65
3rd ,,	21.83
4th ,,	20.53
5th ,,	19.52
Mean	19.78

and after correction for division error and flexure

$$\varphi = -5° 1' 24''.5$$

5. *Final results.*

I finally accept the following values as the most probable results of my determinations of the longitude and the latitude of the four stations in the interior. For the longitude of Mayili I take the mean of the two determinations and for that of N'Kutu I use only that of 1903.

	Latitude	Difference of longitude with Chiloango
Mayili	— 5° 4′ 40″	$-1^m 20^s.9$
N'Kutu	— 4 57 5	— 1 59 .3
Buku Zan	— 4 46 11	— 1 36 .0
Chimbete	— 5 1 25	— 1 53 .2