EAST AFR. PROT.
GERMAN E. AFRICA.
No. 11381

DOMESTIC.
C. O.
11381
RECD
REGISTRY

Office or Individual.

Dm

1907

2 March

Last previous Paper.

(Subject.)

German Geodetic Survey

Transmits Translation [illegible] Report on the measurement of an arc of the meridian in German East Africa by German Experts

(Minutes.)

Pub Dy.

at mee.

K-V.R.

30/3

Topographical Section
General Staff
War Office
Whitehall
S.W.

Forwarded with the compliments of the Director

Operations.

F.O. Paper.

Enclosure 3 in Sir F. Lascelles' No. 2 Africa (S.) (1907)

11,381
REGD 30 MAR 07

Translation of a Report on the Measurement of an Arc of the Meridian in German East Africa by German Experts.

1. Importance.

The extraordinary scientific importance of the whole undertaking rests on its position and the extension of which it is capable. The Arc of the Meridian which cuts the whole of Africa in its greatest length covers 66 degrees of latitude divided almost equally on each side of the equator. It can further be brought into connection with the Russo-Scandinavian survey system through Asia Minor and thus cover 105 degrees of latitude. Such an extension of the material now available by measurements of meridians promises the most interesting and important information as to the size and shape of the earth.

2. Position of the Chain of Triangles.

The first question which arose was whether the triangle chain for the southern portion of the survey should be laid on Lake Tanganyika (the lake route) or to the east of it entirely in German Territory (the land route).

The "lake route" certainly seems to offer the advantage over the "land route" of easier connections, which would make the labour less lengthy and therefore apparently cheaper. But this advantage is only obtainable if a steamer is placed at the free disposition of the parties.

The "land route," which would probably have to be chosen not far from the Eastern shore, offers on the other hand the advantage of easier connections with the base lines (*Grundlinien*) for which there is no room on the shore; besides which, all trigonometrical stations can be made direct use of for mapping, while in the case of the "lake route" the high-lying points of measurement (stations) are of less use for the mapping of the shore, and the use of the trigonometrical points of a "land route" near the shore will be by no means unfavourable to the latter purpose.

The "land route" is therefore undoubtedly to be preferred to the "lake route" as being cheaper, more advantageous, and possible under all circumstances.

3. Scientific Tasks.

The scientific tasks of the measurement of the arc are as follows:

The accurate measurement of a chain of triangles of the first order with an average triangle error of ± 0″·3 seconds which is the degree of accuracy aimed at and obtained in the South African surveys. To attain this degree of accuracy it is necessary to observe each object twenty-four times in all, in order to eliminate the errors of graduation; the instrument should

a well-conditioned and well thought out series of triangles. The personnel of the survey expedition should, if possible, be incorporated with the staff for geodetic measurement later on.

Organisation of Operations.

5. *Personnel.*

The surveying expedition must be composed of at least four Europeans, who will also, however, take part in the reconnaissance: one director, one sub-director, two observers, as well as some subordinate officials, a medical officer and an assistant.

The observers must familiarise themselves while at home with the instruments and methods of measurement and also with the literature of the subject.

Survey and route map sheets on the scale of 1 : 500,000 must be printed in sufficient number of copies must be printed. Measurement and observation forms and schemes for the organisation of the interworking of the different parties must be prepared beforehand. The surveying party will start from the northern end of the lake, where the first points have to be fixed with regard to the extension of the chain farther to the north into the Nubian sphere. In order to avoid the swamps of Lake Victoria, which are infested with sleeping sickness, the Uganda railway must not be used, but the route through the interior of German East Africa must be taken.

The points selected must, as far as the temporary nature of the work allows, be marked at once by permanent stone or earth beacons. In connection with the Uganda Boundary triangulation or a rough, measured base line a rough survey of the triangulation will be made at the same time and marked on the route map. Each point must be shortly described, with a sketch, the route maps must be supplemented by the addition of the large scale sketches and the positions of the permanent marks must be shown upon them.

Special attention must be paid to the establishment of three or four base lines and their base extensions, in the form of one or two quadrilaterals. The choice of base apparatus makes small demands on the evenness of the ground, so that lengths of from 2 to 5 km. can easily be measured.

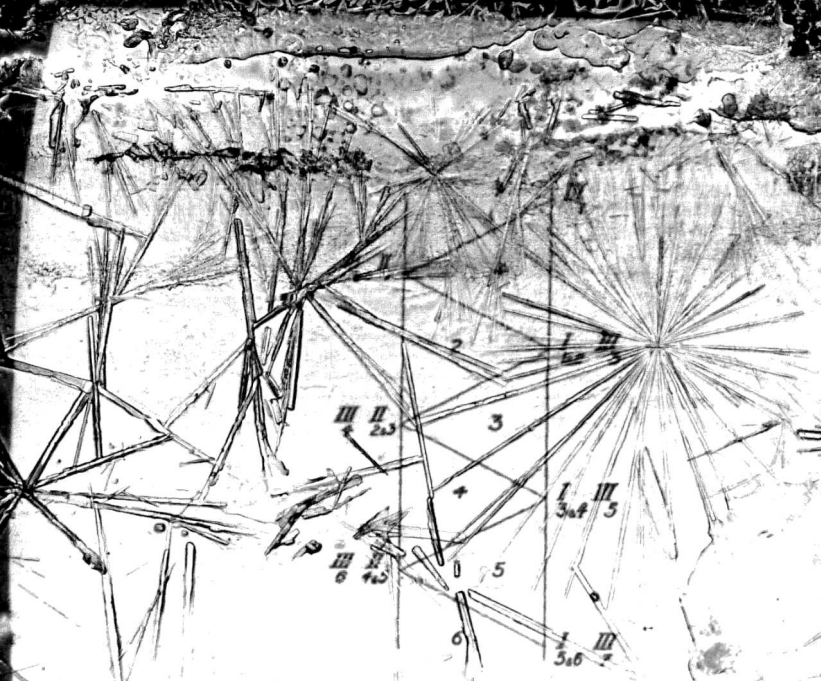
On the completion of the survey, the outward journey of the members of the measurement expedition still in Europe must be arranged by telegraph, which can easily be done by means of the telegraphic offices near the southern end of the lake. The time required for a period of rest for the Europeans participating in the reconnaissance expedition must be taken into consideration in this regard.

The measurement expedition starts from the southern end.

6. *Measurement.*

As observations can only be taken in artificial lights the three sections of the expedition must always be in occupation of the three corners of a triangle. As the measurement proceeds, and the three sections of the expedition move, the following scheme is formed, graphically illustrated below:—

The result is that Sections I and II have rather a different character to Section III, for whereas the latter always has a position for every corner, I and 2 remain at the same point for every two periods during positions. These sections of the expedition are therefore in a position to carry out the observations for latitude and any azimuth measurements required, while the other sections move from one corner to another. But only such measurements can be made during the movements of sections from one point to another as do not require the presence of a party at any other station, for such sections of the expedition are always moving at a time. The measurements of vertical angles for height determinations must be as far as possible simultaneous and as frequent as must also be those (day or night) signals for the determination of differences of longitude and azimuth. These are to be carried out at the same time as the measurement of the horizontal angles.



The [illegible] distance of earthly objects can of course be easily ascertained as [illegible] accurate measurements will suffice, in any case one observation [illegible] one Face). The exchange of light signals can also be quickly [illegible] if only signals between Sections I and II of the expedition are exchanged as they have already made the necessary time observations for [illegible] the lat. etc. There is thus no means of controlling the differences of longitude, but [illegible] hardly matters, if the latitude is fixed twice on two consecutive days. The personal error of the observers will be eliminated in the difference in long. between the extreme ends of any two consecutive rays along which the diff. long. was observed.

Moreover then Section III requires no astronomical observer, Sections I and II [illegible] one.

The surveying expedition must further possess:

[illegible] who is also an astronomer.

[illegible] with astronomical reading.

[illegible] for trigonometrical work.

[illegible] commissioned officers or subordinate officials, i.e.:

[illegible] medical officer.

[illegible] surveyor.

[illegible] one clerk-accountant,

those [illegible] for the early days been those of carpenters, mechanicians and [illegible].

No special reserve seems necessary, and will therefore not be included for reasons of economy. The leader will act as the reserve observer.

Moreover, the leader may carry out magnetic observations and if necessary those for gravity. The leader must have had an astronomical training, otherwise the latitude determinations would sometimes have to be omitted along one side of the chain. As regards the azimuth observations, these can best be obtained when laying down the base-lines and their base extensions and so no special time need to set apart for this part of the work.

The length of the sides of the triangles is to be fixed at between 20 and [illegible] according to the lie of the land so as to avoid as far as may be [illegible] towers for the instruments and lights. Thus about seventy-[illegible] [illegible] for the chain of about 900 km. in length.

[illegible] the [illegible] Expedition.

[illegible] considered by [illegible] the time

[illegible] three triangles with three [illegible] base-lines [illegible] sides of a Triangle requires [illegible] five to six [illegible] [illegible] for the measurement of the angles of a [illegible] [illegible] the determination of the latitude and other subsidiary [illegible] [illegible] will be so reckoned:

[illegible] months.

Preparations at Dover [illegible] ... ... ½

March to the north and [illegible] 1

Measurement of the arc [illegible] 14

" " base-lines [illegible] 2

Accidental delays [illegible] 1

Return [illegible] 2½

Total ... 21

March of the reinforcements [illegible] to the [illegible] expedition) to the [illegible]

[illegible] months.

Preparations at [illegible] ... ... ½

March from [illegible] 2½

Total ... 3

March [illegible]

[illegible] months.

Measurement of the arc [illegible] 18

" " base-lines [illegible] 3

Accidental delays [illegible] 2

Return journey to the coast 2½

Total ... 26

3. Numbers of the Expedition. — Members and Troops.

Each European [illegible] entitled to climb the following [illegible] ... [illegible] packages of [illegible] and 4 of [illegible] 16 in all. [illegible] packages a month. But [illegible] ... be halved [illegible] with him. [illegible] are sent [illegible] beforehand [illegible] earlier from the [illegible] [illegible] and [illegible] passed and [illegible] passed.

Further, 2 [illegible], 1 [illegible], 1 [illegible] thermometer, 1 [illegible] and chair, 1 [illegible] basket, 1 packet of waterproof [illegible] and [illegible] [illegible] for the expedition [illegible] of [illegible] made for [illegible].

[illegible] tools, [illegible] with [illegible] Europeans. From [illegible] we see that the [illegible] ... [illegible] as follows:

Sapper [illegible]

Composed of 4 [illegible] ... [illegible] trained in [illegible], and 1 [illegible] N.C.O.'s.

For these	[illegible]0 porters.
For the transport of instruments and map rolls	16 [illegible]
For supply of consumptio[illegible] ammunition, and [illegible]	14 [illegible]
	140

In addition, 4 heliographists and [illegible] so that each European may have at his disposal 1 heliographist and [illegible] which does not appear excessive for Impororo, Ruanda, Urundi, co[illegible]ha.

Reinforcing Party to Complete the Measuring Expedition.

Is composed of 2 surveyors with two N.C.O.'s, 4 heliographists and 30 soldiers, together with 180 bearers, who are necessary for the larger requirements of the survey expedition.

Measuring Expedition.

Is composed of 8 Europeans, the leader, his second in command, 2 surveyors and 4 N.C.O.'s; for these	240 porters.
Each surveyor requires for a theodolite 2 loads, drawing box and map roll, 2 loads; lamps, tripods, instruments for topography, oil, carbide, 3 loads; heliographs, 1 load; in all 8 loads; for these 4 surveyors require	32 „
In addition to these, for levelling instruments and smaller apparatus, 4 loads; base line measuring apparatus, 2 loads; picquets, axes and cement, 10 loads; petroleum, oil, light, matches, 4 loads; medicine and bandages 2 loads; ammunition, 6 loads; stationery, 2 loads; woodwork and tools for the possible construction of observation towers (*beobstanden*), 4 loads; telegraphic determination of longitude, 3 loads; trade goods, 16 loads; for these	58
Total ...	330 „

Further 8 heliographists and 60 soldiers.

Estimate of Costs.

Items.	In Europe.	In Africa.
[illegible]	Marks. [illegible]	Marks. [illegible]
[illegible] second in command	[illegible]	12,500
[illegible]	4,800	[illegible]
[illegible]	2,400	[illegible]

	Marks.
Yearly [illegible] policy for a leader, if [illegible], for [illegible] marks	
The same for [illegible] in command [illegible] marks	[illegible]
Initial [illegible] for the leader and observer [illegible]	
N.C.O.'s each [illegible]	

	Marks.
Travelling expenses for the leader and observer for one journey, each	1,050
Travelling expenses [illegible] N.C.O.'s for one journey	450
Payment of meteorological observers in the stations, each	200
One saddle animal	270
Monthly keep of a European	150
Monthly charges for one soldier [illegible] pay, 20 marks; clothing, 6 marks; keep, 7 marks; total	33
Monthly charge for one heliographist [illegible] pay, 15 marks; clothing, 3 marks; keep, 5 marks; total	23
Monthly charge for [illegible] pay, 15 marks; keep, 5 marks; total	20
Freight charge for the transport of the material for the expedition to East Africa for [illegible] metre [illegible] ...	32
Freight charge for a load from the coast to a station on Tanganyika through a carrier	40

Equipment for the leader of the Expedition and Observer.

One English tent with bath room, each	400
One table chair and one arm chair	39·50
One bed with mattress, pillow and two mosquito nets	118
Two camel-hair covers	40
One cooking apparatus	49·50
One breakfast basket	65
One bandage and one medicine case	37·50
Waterproof plans (*wasserdichte plane*)	70
Two lamps	100
One saddle with bridle and numnah	15
One pair packing bags	105·50
One petroleum lamp with reserve chimney	20
One writing and drawing box and map roll	30
Total	1,070

For N.C.O.'s the last three items are not to be included, so that the equipment for these amounts to about ... 1,000 each.

a. Cost of **INSTRUMENTS**:—

1. Three small traveller's theodolites by Hildebrand with tripods	1,350
2. Two small sextants or prismatic compass (*prismen-kreis*)	300
3. Five plain plane tables with tripods and telescopic Alidades	[illegible]
4. Two Zeiss field glasses, 12 power, with arrangement for fastening on to the tripod of the small theodolites	300
5. Eight watches (half-chronometers) [illegible] Lange and Sons	1,600
6. Five boiling point apparatus (hypsometers) ...	400
7. Ten compasses, five Schmalcalden compasses, five tape measures, five metre rules, five large aneroid barometers, eight aspiration thermometers, four aspiration psychrometers, eight sling-thermometers, eight plumb bobs, four optical (plumbing) centring instruments, two water levels ([illegible] rohre), two pairs of climbing irons	[illegible]
Carried forward	[illegible]390

	Marks
Brought forward	
8. Four large theodolites with vertical circles and tripods	24,000
9. Four observing umbrellas	100
10. Ten heliographs, with tripods, on the Reitz or Elliot system or a similar one (recommended by Lieut. Schwanz)	600
11. One Jaderin base apparatus with Invar wires (*Invardrähten*)	3,000
12. One level, suitable for the tripods of the theodolites	200
13. Two barographs, two thermographs, two travelling mercurial barometers (by Darner or another) ...	500
14. Two marine chronometers	1,600
15. Tools and material for the building of pillars and observation towers (axes, saws, gimlets, pegs and screws)	400
16. Chisel, and stone borers for stone work	200
17. Stone borer, cement, petroleum, oil, matches, electric observing lamp	600
18. Two barometers with electric contacts for determinations of altitude	400
19. Two chronographs with accessories	500
20. Electric batteries, connecting wires, and time relays	150
21. Barographs, thermographs, barometer, and quick-silver barometer for six meteorological stations ...	1,600
22. Water and breakage-proof packing of instruments ...	2,000
23. Transport of instruments to Europe, reckoning each load as 0·2 cubic metre	400
24. Return transport to Europe	400
25. Incidental	850
Total	44,000

B. EQUIPMENT of the Expedition.

1. Equipment for leader and three observers ...	4,280
2. Equipment for four N.C.O.'s	4,000
3. Ten mules or cross-bred donkeys	2,200
4. Writing and drawing materials, books	500
5. Sixty-eight woollen covers for soldiers and heliographists at 6·50 marks, about	450
6. Dressings and medicine for the Medical N.C.O. ...	1,000
7. Eight infantry rifles, model '98	400
8. Carbine	400
9. Ammunition	2,000
10. Transport of equipment for the Expedition to Africa—4·15 cubic metres	470
11. Extraordinaries	1,000
... ...	18,000

C. EXAMINATORY and MISCELLANEOUS [illegible]

1. Pay [illegible] during preparations in Europe for six months	3,150
2. Same for [illegible] commissioned officers for six months	200
3. Twenty-seven saddle mules for Uhehe Duke ...	825
4. Three [illegible]	[illegible]
[illegible]	[illegible]

	Marks
Brought forward	9,975
5. Preparation of survey maps, etc.	4,000
6. Life insurance, provided that the leader and one observer are married—in round figures	25,000
7. Personal equipment for leader and three observers	6,400
8. Personal equipment of four non-commissioned officers	3,200
9. Outward and return journey of the leader and the three observers	8,000
10. Outward and return journey of the four non-commissioned officers	6,000
11. Pay of the leader and the three observers during the two journeys—each of thirty days	5,370
12. The same for the four non-commissioned officers	2,270
13. Pay of the Europeans during three months sick leave (*Erholungsurlaub*) on the return of the Expedition, at the African rate	17,625
14. For observers at meteorological stations	1,200
15. Pay for an officer for the instruction of soldiers of the Exploration Expedition for one month ...	1,125
16. The same for two non-commissioned officers ...	888
17. The same as in 15 and 16 for the soldiers of the Survey Expedition	1,575
18. Sixty soldiers for one month's instruction ...	1,980
19. For guides, presents to chiefs, assistant carriers, felling of trees, carrying stones for making cairns (*steinetragen*) etc.	5,000
20. Unforeseen expenses	4,838
Total	105,000
Total, costs 1, 2, 3 and 4	167,000

[illegible] EXPEDITION.

[illegible] of the Expedition for one month

[illegible] ay of leader ... ...

[illegible] ay of deputy 1,250

[illegible] ay of two non-commissioned officers at 425 marks each 850

Victualling for four Europeans at 125 marks ... 500

Thirty soldiers at 33 marks each 990

Four heliographists at 23 marks each 92

150 carriers at 20 marks each 3,000

... ... 7,801

... twenty-four months 187,368

Each European has with him [illegible] loads of victuals and equipment a month which make together 72 loads, which thus altogether are 24 × 12 = 288 loads. Eighteen of these loads are for each European, altogether 72, making allowance for the disposition of the number of porters. 216 loads of 40 marks each remain for the forwarding agent to send to the lake. This makes in initial expenses ... 8,640

Exploration Expedition in toto 196,008

Every month 12 × 40 marks = 480 marks are requisite in initial expenses. Just for every month more or less that [illegible] 480 marks = [illegible] are [illegible] ... [illegible] the same total.

a. March of the Reinforcements Likely to Join the Main Expedition.

Cost for one month—

	Marks.
Pay of two observers at 900 marks each	1,800
Pay of two non-commissioned officers at 225 marks each	450
Victualling for four Europeans at 125 marks each	500
Thirty soldiers at 33 marks each	990
Four heliographists at 23 marks each	92
180 carriers at 20 marks each	3,600
	7,432

Thus for three months 22,296

Renewal of supplies of Reconnoitring Expedition, trade goods, objects of daily use, as also the return transport of 19 loads of instruments requires the transport of 40 loads through the forwarding agent at 40 marks each, which makes in initial expenses 1,200

Month of Expedition *in loco* 24,000

b. Measuring Expedition.

Costs for one month—

Pay of leader ...	1,500
Pay of deputy ...	1,125
Pay of two observers at 900 marks each ...	1,800
Pay of four non-commissioned officers at 900 marks each ...	1,800
Victualling of eight Europeans at 125 marks each ...	1,000
Sixty soldiers at 33 marks each ...	1,980
Eight heliographists at 23 marks each ...	184
330 carriers at 20 marks each ...	6,600
	16,639

Thus for twenty-six months 406,614

Each of the four Europeans taking part in the Survey Expedition is entitled to 3 × 26 = 78 loads of victualling and equipment, thus together 4 × 78 = 312 loads. 5 for the four Europeans of the second division, 4 × 29 = 87 loads. Further this may be augmented 18 for each one, making allowance for the disposition of the number of carriers = 360 loads, altogether 4 × 60 = 240 loads, are chargable. Therefore there are 312 + 240 = 588 loads at 40 marks each to be forwarded by the agents. This makes in initial expenses 23,520

Measuring expedition *in loco* 430,134

In initial expenses × marks 1[illegible] It is used in one month and a half, forwarding 3 times, one will cost 900 marks. Therefore each month, making loss along the Survey Expedition takes will cost 16,599 marks, [illegible]

[illegible]

[illegible] Europeans [illegible] with [illegible] and two non-[illegible] Kisseh [illegible] One [illegible]

[illegible] Pay for two [illegible] years at [illegible] marks each ... [illegible] Marks.
[illegible] each ... [illegible]
Pay for two [illegible] commissioned officers at [illegible] each ... [illegible]
Victualling for [illegible] Europeans at 125 marks each ... [illegible]
10 soldiers at [illegible] marks ... [illegible]
65 carriers at [illegible] ... [illegible]
Transport of [illegible] ... [illegible]
[illegible] stations [illegible] kilogrammes ... [illegible]
Freight for 6 [illegible] Agent at Sendja ... [illegible]
Unforeseen ex[illegible] ... [illegible]

Telegraphing s[illegible] Kisseh ... [illegible]

c. Terrestrial mag[illegible]

For magnetic [illegible]'s theodolite 4 more carriers [illegible] each are required. Thus, monthly [illegible]
20 [illegible]
20 mar[illegible] ... [illegible]
For 29 months [illegible]
For the [illegible] apparatus 18 more carriers [illegible] marks. These are necessary. Thus, [illegible] marks.
For 24 mo[illegible] ... [illegible]

For magn[illegible] ... [illegible]

Total ... [illegible]

[illegible] division ... [illegible]
[illegible] division ... [illegible]
[illegible] titude calculations ... [illegible]
[illegible] magnetism and gravimetry ... [illegible]

Sum total 16,859

The amount, in round figures, 940,000 marks, is divided into four years, so that 240,000 marks on an average will be required yearly.

(Signed) { Dr. E. Kohlschütter, Bearbeiter.
Prof. Dr. F. R. Helmert.