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Road-Making and Surveying in British East Africa

Author(s): G. E. Smith

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aiken" = "where there is grease," a favourite hunting-ground, the reputation of which has been handed down by tradition. The natives say that there was much more water there previously; that one of its largest lagoons, dry to-day, was always filled; and that they could camp in any part of the wide lost valley, which is not the case to-day.

This route, between Lake Belgrano and Lake Buenos Aires, is interesting because it demonstrates the ancient distribution of waters in Patagonia and their subsidence. The same number of terraces can generally be counted from the main surface of the plateau: five important ones 165 feet in height more or less; and four varying from 65 feet to 20 feet, as though the causes which brought about the disappearance of the great lost lakes and rivers had been produced contemporaneously. Likewise this part, better than any other, confirms the opinion, already generally accepted, that Patagonia was covered by an extensive ice-cap, at least as far as the present coasts. The great granitic and quartziferous erratic boulders which proceed from the main chain of the Cordillera prove this, and when once the ice disappeared, the climatic conditions permitted the permanent existence of great rivers and lakes which eroded the surface, which was gradually uplifted. It is indubitable that a great portion of the lavas which are seen on the plateau to-day were deposited prior to the glacial period, but it is also certain that the eruptions have continued up to relatively very recent times, as, in some points, not the slightest vestige of erosion can be noticed on its surface, whilst at others it is polished and striated by the ice.

(To be continued.)

ROAD-MAKING AND SURVEYING IN BRITISH EAST AFRICA.*

By Captain G. E. SMITH, R.E.

ON May 6, 1895, I received orders to proceed forthwith to Zanzibar, to assist the late Captain B. L. Selater, R.E., in the completion of a road from Mombasa to the shores of the Victoria Nyanza, in order to improve the communications between Uganda and the coast. It was to be a continuation of the "Mackinnon road," which had previously been made by Mr. Wilson under the Imperial British East Africa Company as far as Kibwezi, a distance of 180 miles from Mombasa, and was to be of the simplest kind, unmetalled, and, in fact, the roughest track along which a bullock-cart would go. Captain Selater, who had previously had two years' experience of rough road-making in Nyasaland (British Central Africa), remained in England to collect the necessary stores for the expedition, while I went out in advance to organize the caravan.

On June 2, 1895, I reached Zanzibar, where I found more than usual

* Read at the Royal Geographical Society, June 26, 1899. Map, p. 352.

difficulty in getting porters, as several large caravans were on the point of starting. It was not until the middle of July that we could collect one hundred men, sufficient for my first start. Captain Selater, who had arrived at Mombasa in June, remained at the coast to organize other caravans, the last of which did not leave until October, when our caravan became approximately as follows:—

Europeans: in command, the late Captain B. L. Selater, R.E.; second, Lieut. G. E. Smith, R.E.; assistants, four non-commissioned officers R.E. Indian coolies from Karachi, 100 Swahilis, 100 Askaris, 200 porters. Zulus, 6 bullock-drivers. Up-country natives, from 300 to 500.

We took with us twenty bullock-carts, and had considerable numbers of oxen, donkeys, cows, calves, sheep, goats, etc., besides seven ponies for our own use. The bullock-carts we employed were built at the Royal Arsenal, Woolwich, with two wheels and a pole. They were light and handy, and were usually drawn by three yoke of oxen. Their wheels were so well made that after two years' hard wear we had not broken a single one. They would carry about 1500 lbs.

On July 17, 1895, I started from the coast with our first caravan, with the object of forming a *dépôt* and beginning the road, whilst Captain Selater from the coast was to organize fresh caravans and start them off up country. Until October I was in advance, prospecting and beginning the road; afterwards Captain Selater was usually on ahead, and I was finishing up the work behind. It was seldom that our men were all together; indeed, usually we had several camps, each with a white man in charge of it, working at various sections of the road or at the bridges that we built. I have not space to describe such arrangements in detail, nor would a description of all our marches and countermarches be of interest to any one save myself. Briefly I may remark that in two years I shifted camp about three hundred and twenty times, and marched some 5000 miles, which earned me the Swahili sobriquet of "Bwana Kongoni," or hartebeast, because they said I ran about so much.

The late Captain Selater was anxious, if possible, to make a good map of the country, and the map-making fell to my lot. For the most part I did it in my spare time, taking a day or two, when I could get away from the supervision of the road, for ascending suitable peaks to obtain my trigonometrical observations, whilst my plane-table work or detail was put in as occasion served on the line of march. I had the very great advantage of going several times over most of the country, so that I could work in my detail gradually, first getting in the more conspicuous hills, and afterwards filling in the minor features. This allowed me to get much more accurate results than if I had had to work in everything as I went along the first time, and gave the opportunity of thoroughly testing my work and making corrections where necessary. The Swahilis, who seldom lose the chance of inventing a nickname, also

called me "Bwana Panda Mlima," or "the hill-climber," from the number of hills which we ascended for trigonometrical work.

For the first 180 miles, that is, as far as Kibwezi, the road runs through an uninteresting country, covered with dense thorn scrub and badly supplied with water, the march through the Taru desert being the worst in that respect. Fortunately for us, Mr. Wilson had already made this section of the road; and now the traveller is still more fortunate in being able to pass through this inhospitable country in the train. The land rises sharply in the first 20 miles to a height of nearly 1000 feet, and afterwards more gradually to Kibwezi, which is about 3000 feet above the sea. At Kibwezi our work began with a stiff bit of jungle-cutting over a very rough bit of lava, a couple of miles of graded road over the southern spurs of the Mbinzau hills, and a few miles of bush-cutting, which brought us fairly out on to the Kiboko plains. Up to this point the country is unsuited to cattle, and before the railway reached Kibwezi, many were lost in running transport through this section. The tsetse fly is found at various places, especially near Kibwezi, but I think most of the loss was due to the poor quality and scarcity of the grass and the difficulty of finding sufficient water.

Once the Kiboko plains are reached the country becomes much easier. For our purposes no work was required on the open grass country, with the exception of making a few "drifts" or fords over the rivers to be crossed, which, as it happened, were met at suitable distances for camping. After driving a caravan of carts three or four times across these plains the trail became well marked, and, except in very heavy rain, was good going. Game was abundant, large herds of zebra, hartebeest, wildebeest, and various species of antelope being met with. From one little hill I saw 3000 head of all sorts, including rhinoceros and giraffe.

A good deal has been written of late with regard to preserving the big game of Africa by people who forget that there is another side to the question. Whilst I was in the country where rhinoceros were most common, I lost one man killed and one badly wounded, who had not in either case attacked the rhinoceros. Whilst quietly marching through thick bush, I have had rhinoceros charge suddenly out of it three times. Similar experiences often occurred to other members of the expedition. One of them was knocked down by the shoulder of the animal charging down a narrow path. More than once, when crossing the open plains, I have fired bullets wide of a rhinoceros to drive him off from our track, and have been obliged in the end to kill him because I was not prepared to take the risk of his charging my caravan. A rhinoceros is a thick-skinned animal, and will not take a hint. The elephant is sometimes dangerous without being attacked; but any traveller who has seen the havoc caused by a herd of elephants in a native plantation will understand the joy of the natives when they are killed.

About 50 miles beyond Kibwezi the road reaches Muani, where we

built our first depôt. It is at the foot of the Ukamba hills, about 4600 feet above the sea, and near a good stream. The Wakamba were soon persuaded to bring in food, and we started a thriving trade. I may remind my audience that money in that country was non-existent, unless the various kinds of trade goods, such as calico, beads, brass wire, iron wire, etc., may be called money. Trade is by no means simple. The demand varies from place to place and from time to time, and therefore trade goods have to be designed to satisfy varying needs. Considerable difficulty may be caused if the traveller has not the right sort of calico, of which there were about ten kinds, or of beads, of which we carried nine kinds, or of the other trade goods. And the question is further complicated by the fact that each commodity of trade has an enhanced value for every mile's journey from the coast. When I add that for months after our final start we were unable to get any loads forwarded to us from the coast, owing to the insurrection of Mbaruk and other causes, some of the difficulties of barter and transport may be understood.

Muani may be said to be the beginning of the healthy country, beyond which fever is practically unknown till Kavirondo is reached. The air is cool and bracing, and extraordinarily clear. The sun does not feel excessively hot, and the nights are pleasantly cold.

After 12 miles more of easy work the country rises sharply to the Athi plains. A height of nearly 1000 feet has to be climbed in the next march, making the altitude above the sea over 6000 feet. The road hereabouts was troublesome to locate, as there were so many alternative routes, and I had to examine a good deal of country before coming to a conclusion. In this section we made a graded road, which entailed much earth-work. For the style of unmetalled road we were making, we used, in climbing hills, to endeavour not to exceed a gradient of 1 : 20, or about 3°; but we did not hesitate to put in a bit of 1 : 15, or even steeper, if we saved much work or distance thereby. A new-comer seldom realizes that for a bullock-cart, especially if the drivers are unskilled, a sharp turn on a gradient is much the worst fault in a road. Bullocks must have a straight pull, and you must allow sufficient width at the turns for a caravan to double-team their carts in going up steep or long hills.

A hundred yards or more of 1 : 8 gradient is less objectionable than a couple of sharp turns. If South African waggons are to be used, much easier curves are necessary, unless, of course, they are fully compensated. We saved some work by making the grades for a cart going down country steeper than for one going inland; for the latter is, as a rule, the heavier laden. When we were laying out the road in hilly country, we were careful to grade it well. We had to do a good deal of earth-work in such cases, and should it ever be advisable to improve the road, all the work we did would help; whereas if a road is badly

located, an entirely new road would have to be laid out in order to improve it.

By the end of 1895 we had completed the road to the Athi plains, and in another month it was open as far as Kikuyu. The Athi plains required but little work beyond drifting the rivers, when once the best route across them was decided on. We did not pass through Machako's, the capital of Ukamba, but left it one march to the right. Mr. Ainsworth, the sub-commissioner, has since connected it to the Selater road by a branch road.

Kikuyu became our headquarters in the early months of 1896, and remained during the rest of our expedition the advanced base from which we drew our supplies for many months. It is a delightful country, from 6500 to 8000 feet above the sea, with a pleasant healthy climate, and with plentiful supplies of food. It is well watered, and has a rich soil. Originally the whole country was forest. The Wakikuyu cleared the middle of the forest for their plantations and villages, and left a thick belt to protect them from their dreaded enemy, the Masai. Timber is still plentiful, but, owing to the more peaceful times which have been established under British rule, they are now rapidly cutting down the forest that remains, as they prefer the newly cleared land for their plantations. The Kikuyu country lies along a line of heights running in a north and south direction, and inhabited chiefly on the eastern side, which slopes gently to the basin of the Athi river and the headwaters of the Tana. To the west the land drops steeply, a fall of 2000 feet, to the Great Rift valley, which extends as a trough-shaped depression north and south for several hundred miles. It has a separate water-system of lakes or marshes with no outlet, fed by rivers of no great length rising in the high mountains on either side. At intervals volcanoes of recent geological times are seen along it, and the floor of the valley is for the most part formed of lava or basalt, and hot springs and steam-jets are not uncommon. Its eastern wall is known as the Kikuyu escarpment, and here we found our heaviest bit of work.

From Fort Smith the road passes through a hilly country with some forest for about 14 miles, until the edge of the escarpment is reached. We had been warned by everybody we had met of the dangers of this bit of road, owing to the irreconcilable Waguruguru, who had an unpleasant habit of cutting up stragglers from caravans in that part, and with whom a constant petty warfare had been waged by the garrison of Fort Smith. Captain Selater took half a dozen Askaris and boldly went into their country to try and get on terms with them. They turned out in hundreds, spoiling for a fight, but Selater succeeded in explaining that he had come to shoot hippopotamus and to buy food and make friends. After a short hesitation, they conducted him to a swamp, and gave him every assistance in showing him how to get near the game. By the time he had shot at two or three hippopotamus they

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were all good friends, and apparently had come to the conclusion that the Englishman was not such a bad kind of person after all. Captain Selater had a wonderful knack of making friends with natives. In the course of the next few months I bought about 170,000 lbs. of food from them, and became a blood brother of the leading chiefs. The only trouble was that their friendship became a trifle embarrassing, as the same men who had previously made the road dangerous for all small parties felt hurt when I refused to go and live among them for the rest of my life.

At about 14 miles from Fort Smith we reached the top of the main Kikuyu escarpment, the descent of which to the Kedong river employed 300 men for about four months. For 300 yards in one place we had to blast our road out of the face of a cliff of hard grey crystalline lava. The outer portions we could displace with crowbars and levers, but as we worked into the side of the hill we had to blast. We used about 130 lbs. of dynamite and about 50 lbs. of powder. It was amusing to watch the intense interest of the natives in what they called the white man's witchcraft, the Wakikuyu being especially pleased by watching a large rock bounding down the mountains; whilst the Masai greeted that or the explosion of the blasting charges by exclaiming, "Eigh! eigh! eigh! eigh! Ngai!"

For about 30 miles from the Kedong river to Naivasha lake, little work, except some clearing of bush, was required, but at the north end of the lake the two rivers Morendat and Gilgil had to be bridged. We built simple trestle bridges over them. This took some time, as we had to cut our timber in the juniper forests which clothe that part of the escarpment, and to cart it several miles. The Morendat bridge was 120 feet long, with a 15-foot roadway supported on five framed trestles, whilst the Gilgil bridge was 35 feet long. Both these rivers are liable to prolonged floods, so that drifts would not have been reliable.

One march beyond the Gilgil river we had some heavy earth-work in descending towards Lake Elmuteita, another small independent lake beautifully situated close under the Subugo Rongai hills, which falls in terraces towards it. Three marches further on we had to bridge the Molo river, which, although usually an inconsiderable stream, is unfordable for a month at a time during the rains. Two marches more bring the traveller to the Eldoma ravine and fort. The last march required some earth-work in climbing the foothills of the Mau escarpment, and a minor bridge; but from the Kedong river to the ravine the road crosses plains, and required little work except what I have mentioned.

The bridges which we built were designed to carry a load of 3 tons, the trestles being strong enough to support much more, so that by putting in more road-bearers they could easily be strengthened to carry loads of 10 tons, if it were ever necessary.

Whilst we were busy on this section of road, a lion attacked one of our camps, and was killed by our men. The Masai identified it as a man-eater, which they said had killed a hundred of them. However that may be, he was exceedingly fat; and as it happened that we had at that time run out of cart-grease, we boiled down his carcase and obtained about 70 lbs. of fat. He kept our carts well greased for about six weeks.

Beyond the Eldoma ravine we reached the ascent to the high table-land called the Mau plateau, which forms the watershed between the rivers flowing westwards to the Victoria Nyanza, and so feeding the Nile, and those which flow eastward into the water-system of the Great Rift valley of Masailand. From the Eldoma ravine, 7200 feet above the sea, the eastern slopes rise to a summit-level of about 9500 feet in a distance of 15 miles. They are clothed with thick forest, the lower portion consisting of very large trees of juniper and other kinds which furnish good timber, whilst a dense undergrowth of very tough brushwood makes road-making a difficult and tiresome operation. The upper slopes are somewhat easier, as the forest gives way to open grass-land, intersected by belts of thick bamboo jungle on the higher levels. The old caravan road, which was in use till the autumn of 1896, leaving the Ravine fort, often called by the Swahili word "Shimoni," crossed at once the great ravine of Eldoma, and, plunging into the dense forests I have described, passed north-westwards to the headwaters of the Nolosogelli river. There changing its direction to south-south-west, it follows the left bank as far as Mumia's, where the river is called the Guaso Masa.

This section from the Ravine fort to Mumia's in Kavirondo was notorious for the large losses incurred by caravans. Losses of three or four per cent. were not unknown, whilst it was rare for caravans to get through without casualty. It was eleven marches from the ravine to Mumia's; and until Kabras was reached at the eighth march, no supplies—except perhaps game—could be obtained. Even in fine, dry weather the marches were arduous, and the nights on the top of the Mau very cold; but during the rains, which in that part often continue for many months, the road was dreadful. Through the forest in the ascent of the Mau (three marches) the road was steep, winding, and narrow, and thick undergrowth which had never been properly cleared allowed insufficient headroom for loaded men, and so added immensely to their fatigue. After passing the watershed, the road, although through more open country, was still very bad, as marshes had often to be crossed which were at times deep. At the Eldoma ravine, food used to be issued to each man to last him as far as Mumia's. Experienced porters would make this last out; but the improvident, of whom there are usually many in a Swahili caravan, would often have finished their rations when hardly halfway across the uninhabited region; then, unless the caravan

leaders were skilled hunters, the weaker men perished miserably. The truth, as I have endeavoured to describe it, was sufficiently bad, but various sensational and exaggerated accounts have been published from time to time. A skilled caravan leader could reduce the casualties by taking care that the porters did not sell their blankets or waste their food, and the sacrifice of a load might save a life; but no care could prevent dysentery and pneumonia from attacking the weaker men on the inclement uplands of the Mau.

When I asked one of my headmen what he thought of the road across the Mau, he replied, "Why, sir, the Mau is nothing now; there is no mountain to climb any longer." Allowing for flattery, this shows that the natives appreciate a graded road. One distinguished officer estimated the saving of life caused by it as three or four men per month. From May to November, 1896, we had from two to five hundred men working in this region, of whom we lost but one; and as his death was probably due to heart disease, our loss through climate was *nil*. This I attribute chiefly to the issue of an increased ration to our men, which we were able to afford, owing to the efficiency of our cart transport. We had a further advantage, owing to the fact that, never having large numbers of men far away from the advanced end of our road, we could continually fill stores with food near to our working parties, and issue it every few days, thus reducing to a minimum the ill effects of improvidence among the porters. Furthermore, if a man became ill, we could transport him in carts to a less inclement climate.

Our orders were to make the road by Eldoma Ravine fort and Mumia's to Port Victoria. It had been thought until 1895 that the Eldoma ravine could not be avoided by either road or railway. It is a serious obstacle, 300 feet deep, with sides which are for the most part precipitous and nowhere of less slope than 1:1. Mr. Martin, when he was in charge of the Ravine fort, however, found an easy way to avoid it; and in 1896 Captain Selater, making a more exhaustive examination of the country, discovered a direct route round the ravine to Mumia's by the Nandi country, which had been practically unknown until Major Cunningham's punitive expedition to it early in 1896. This country, being covered with thick forest and intersected by minor features, was a very difficult one in which to lay out a road; but Captain Selater, after much labour, laid out an excellent line up a main spur, hitting off very skilfully those parts of the country where bare patches relieved us of the necessity of clearing forest. With a ruling gradient of about 1:20, the summit-level of the Mau plateau is reached in about 15 miles, of which two-thirds are through thick forest. From the summit-level the country is more open, and only occasional belts of forest are crossed as the road gradually descends into the Nandi country. Four minor rivers had to be bridged in this section; but as plenty of magnificent timber was at hand, this was a simple matter, and each bridge was a single

span of from 20 to 30 feet. The piers on either side were built of rough timber crib-work, pinned at the angles with 2-inch trenails of hard wood, driven home through auger-holes. The road-bearers were of large timbers, with a rough roadway fixed in a similar way.

Nandi is now reached in four or five marches from the ravine. It is a charming country lying between 6000 and 7000 feet above the sea. It is chiefly pasture of good turf, and the natives live by their flocks of goats and fat-tailed sheep and herds of humped cattle, which are here of a larger breed than any other I have seen in East Africa. They also cultivate millet and other native cereals to a small extent. It is a country of hills and valleys innumerable; in every valley is a clear stream rushing over a rocky bed. In Nandi itself you could camp at any moment, and be sure of water in the nearest hollow. The Wanandi are akin to the Masai both in language, race, and habits, and, like the latter, used to raid their weaker neighbours extensively. They do not much like being kept in order by an Englishman in the midst of them, and are not to be entirely trusted yet—at any rate, at a distance from the caravan road. A fort was built at Kamsikak, and was garrisoned by some of the Nubians, who have since mutinied. We reached Nandi in October, 1896, although we had not finished all our bridges until somewhat later.

Nandi occupies a plateau, which is sharply defined towards the south and west by what is generally known as the Nandi escarpment. To the south this is a formidable obstacle, as the land drops very steeply some 2500 feet. Fortunately for us, to the west the fall is less abrupt, although the forest which clothes the slopes and foot of the escarpment is thick, and one deep river, the Gimonde, needed bridging. We had about 12 miles of forest to work through, and about 1200 feet to descend, before reaching the open plains of Kavirondo. The Itsuka and two inferior streams had still to be crossed to reach Mumia's fort and station, but otherwise scarcely any further work was required. The bridge over the Itsuka river was the most considerable work, consisting as it did of four 20-foot spans, supported by trestle frames. From lack of carpenters, this bridge could not be finished until January, 1897. Meanwhile Captain Selater had finished what little clearing work was required up to Mumia's, and, crossing the Guaso Masa river, had driven carts to Port Victoria, on the Victoria Nyanza, on the last day of December, 1896. The Guaso Masa river is liable to heavy and prolonged floods, and, when low, is generally 150 feet wide. To bridge it would have been a considerable work, as no timber of sufficient size could be obtained within 20 miles of Mumia's. We decided, accordingly, to build a ferry-boat suitable for taking carts across.

Early in January, 1897, Captain Selater started for the coast to begin other work to which he had been appointed, whilst I remained to finish the ferry-boat and to complete the data for my survey as far as

Mumia's. We found Kavirondo by no means so healthy as the higher country between Kikuyu and Nandi, and in this part no European of our party escaped without suffering from more or less severe attacks of boils, or fever, or both. It is a thickly populated country, treeless, and much cultivated. The natives go about without any clothes whatever; both sexes are equally indifferent to them. This is a drawback, as, their only want being a few beads, they have no adequate inducement to work, and it is difficult to persuade them to do so. There is scarcely any game in their country except crocodiles and hippopotamus. The country is chiefly noted for its thunderstorms and hailstones.

The construction of a ferry-boat I found a matter of some difficulty, as I had not a proper supply of stores for the purpose, and, except for a few spikes and nails and some steel wire rope, I had to make or improvise all I wanted. My timber for planks I had to cut 25 miles away and cart to the spot, whilst suitable stuff for knees I obtained in the Mau forest and carted over 100 miles. I had no oakum, no white lead, no pitch, no tar. I had to make my own bolts, and most of my spikes. I even ran short of iron, and had to use native smelted iron for finishing my spikes. I built a kind of punt, 36 feet long, 10 feet wide, with sloping ends and flat bottom. I used old gunny bags and a native fibre called kongi, steeped in cart grease and hippopotamus fat, for caulking the seams. After much labour, we managed to make a ship which floated, and which was certainly of great strength and weight. I adopted a simple method of warping her across the stream, and finished my work at the end of March, when I started for the coast, and, marching hard, I reached Mombasa in the middle of May, 1897.

I found Captain Sclater preparing to start up country again. He was unwell, but, becoming better, determined to proceed. I left Mombasa by the next opportunity, and arrived in England at the end of June, 1897.

Soon afterwards I learned, to my great regret, that Captain Sclater was again very ill with fever. He was ordered home, but it was too late. The day before his ship started, symptoms of hæmaturic fever developed, and he became too ill to travel, and a few days later he died.

Among many men whom I know who are successful in dealing with the African native, I think he was second to none. He made them all love him. His tact and patience with them was inexhaustible, and his cheery manner always seemed to put them into a good temper. His name used to work like magic, and a man who claimed friendship with "Bwana Saleta," as they used to call him, was sure of a friendly reception. In Kavirondo I met with a native bard who used to greet passing caravans with an ode celebrating his praises accompanied on a native guitar.

The "Sclater road" to the Victoria Nyanza lake took about two years to accomplish. It is 400 miles long, and cost about £17,000.

The remainder of my paper is concerned with my survey work; I

cannot, I am afraid, avoid making it rather technical, although I have relegated to appendices the parts which seem to me only to concern specialists.

On leaving the coast in 1895, my object was to endeavour to complete a triangulation over as large a portion of the country as possible, filling in as much detail as I could with the plane-table. I knew that the first 100 miles would be difficult, owing to the jungle which covers it, and I hardly expected to be able to triangulate from Mombasa itself, especially as, until Kibwezi was reached, I knew I could not spare more than a day or two for the purpose. I hoped from Ndi and other mountains to connect my work with the triangulation carried out to the southward of the road by my brother consul C. S. Smith and myself whilst engaged on the Anglo-German boundary commission in 1893. I had, however, the misfortune to meet with an accident which disabled me for several days, so that I had to be carried, and could not survey. Indirectly my accident, disorganizing for a day or two my caravan, probably encouraged one of my men to desert with his load, which contained my sextant, nautical almanacs, mathematical tables, and other useful books. It was some time before I obtained fresh copies, and, having no almanac, I was prevented from doing any astronomical observations. I afterwards regretted that I did not take sights for azimuth at Mbinzau; but I did not do so, as no sights are satisfactory when not worked out at the time.

I did not succeed in doing any work of value until some time afterwards, and I added nothing to our geographical knowledge until Kibwezi.

The instruments which I used were as follows: One 5-inch transit theodolite, by Troughton & Sims, reading to minutes of arc; one 6-inch sextant by Mr. Porter (late Carey); one artificial horizon; two plane-tables; aneroid, thermometers, etc.

For the methods of calculation employed, I must refer inquirers to Appendices I., II., and III., and to the 600 pages of foolscap on which the computations are worked out.

Near Kibwezi a very good peak called Mbinzau rises 1500 feet above the plains, and from its summit I began my triangulation with a set of theodolite angles. Among the peaks I observed were five which I identified as peaks whose position and height had been determined in 1892.* In order to fix my starting-point more accurately than I could do with a plane-table, I employed the method of resection, described in Appendix II., from which it can be seen that I obtain the most probable azimuth and position, and can at once determine the probable error of the result. The latter can only be looked on as a rough guide, as the number of observations (five) is not sufficient to make the theory of

* A sixth was observed with such results as to show the necessity for its revision. It turned out that an error in calculation had been made.

least squares rigidly applicable. In this case my probable error was 48 feet in distance from one of my former points. For the benefit of the unmathematical among my audience, I may explain that where several discrepant results are obtained for the same quantity, by an examination of the errors of the results, a quantity called the probable error can be obtained, which assigns a limit within which it is an even chance that the true result lies. This limit can be computed with precision where a large number of results are obtained; where the number is small, the probable error gives only a rough idea of the accuracy obtained, and in the present paper it is in this sense that my results as to probable error must be understood.

I afterwards obtained a good astronomical azimuth at Lake Naivasha, which gave a discrepancy with my resected azimuth of $3' 38''$. This correction altered the position of Mbinzau 120 feet in latitude and 340 feet in longitude, but my original position was sufficiently near for a first approximation.

About 40 miles beyond Mbinzau I obtained an excellent observation station at Imali, a sharp peak some 2000 feet above the plains at the south-west of the Ukamba country, from which I could again see several old friends. Using the resected azimuth, I cut in my position from them, so obtaining a base which was sufficiently good for a first approximation, and which had only to be slightly altered later on when I could test my scale by latitudes obtained at Naivasha. From this point onwards the work was much simpler, and, as may be seen from the diagram of triangulation, I reached Naivasha with six fairly well-shaped triangles, of which all save the first have all the angles observed. This point, close to the bridge over the Morendat, was a very good place for astronomical work. It is situated in the centre of a small plain about 10 miles across from east to west, and to north and south the mountain masses are more distant and symmetrical—a very important point in getting an accurate latitude, in order to avoid local attraction along the meridian. I observed eight pairs of circummeridian stars, each star being on the average observed ten times, and, combining these 160 individual observations, I obtained a latitude with a probable error of 83 feet, a result which could probably not be much bettered with a 6-inch sextant reading to $10''$. I also obtained four pairs of east-and-west star observations of azimuth, which worked out with very small errors. The above gave me the data for arriving at a second approximation with my triangulation. I oriented my triangulation on this azimuth, and corrected my scale so that my triangulated latitude should agree with my observed latitude at Morendat. I now had obtained the second approximation for the latitudes and longitudes of my first seven observation stations. Two more well-shaped triangles brought me to Loldiani, the highest peak in the Mau range of mountains, and also the highest point I ascended—10,000 feet above the sea.

From Loldiani to Mumia's, which was my final station, I proceed with six observation stations. In only one case was I able to observe three angles of the triangles, but where this could not be done, I solved two or more triangles with two angles observed, in order to obtain reliable checks on my work.

At Mumia's, which is situated in a wide plain, and is probably free from local attraction, I observed very carefully for latitude seven pairs of circummeridian stars with about ten observations for each star. Combining these 140 observations, I obtained a latitude with a probable error of only 96 feet. My sights for azimuth comprised four sets of morning and evening observations of the sun, giving a probable error of 7". Comparing the above results with those obtained by triangulation, I got an error of azimuth of 1' 58", whilst the discrepancy in latitude was only 30 feet. It will be seen from the above that at the three points Mbinzau, Morendat river, and Mumia's, where I can compare my triangulation results with previous work or with astronomical determinations, the residual errors of latitude are practically nil, whilst those of azimuth are not great.

Consequently, we can infer that the orientation of my series of triangles is not far wrong, and that being so, the good agreement in latitude shows that the scale is approximately correct—provided that the triangulation is consistent with itself. This is shown in the early part from Kiu to Loldiani by the accuracy with which Kenya is fixed from four observation points, the probable error in latitude being only 19 feet, whilst in longitude it is 72 feet; and in the latter part by the good agreement obtained in the determination of other outlying points, such as Elgon.

The general accuracy of the map which I claim from these errors, which I have quoted at some length, is as follows:—

- (1) All latitudes of main points correct to within 1", or 100 feet.
- (2) Longitudes * correct to 800 feet, or about 8"; errors of longitude, if any, being due to error in azimuth.
- (3) Azimuth correct to 1' of arc.

I claim, however, that the map is consistent with itself, so that if at any future time the longitudes of Mumia's and of Mbinzau be determined by telegraph, the whole of my work may be corrected by a slight change of orientation and scale.

Turning now to my computations of height, I have combined my observations in such a manner as to obtain two independent series from start to finish. One series consists of reciprocally observed vertical

* Longitudes depend on longitudes of the Anglo-German Boundary Commission of 1893, which themselves depend on the longitude assigned to Mount Jombo, near Wanga, in the Admiralty Chart. It is probable that a constant correction may have to be applied to all these longitudes on the computation of any one of them by telegraph.

angles throughout, whilst the other is equally complete as far as Loldiani, although beyond it depends on intersected points, of which in every case two or more are taken. These two series are equivalent to a single series of over 600 miles, closing on the same point. The closing error was only 25·5 feet, a surprisingly good result with a 5-inch theodolite. I used the methods employed in the Indian survey, and a good idea is formed of the regularity of the results * by examining the coefficients of refraction which I obtained from each pair of reciprocally observed angles, and which are nearly constant until the main watershed of the Mau are past, whilst afterwards they regularly increased in value to my final station. Perhaps the points of most general interest in my results are some of the determinations of height which I obtained. I have already referred to the position of Kenya † and its small probable errors. I now wish to point out that its height has been considerably exaggerated. I have worked it out from six different positions, and with a probable error of 19 feet I assign to it a height of 17,180 feet.

The next highest peak which I observed was Donyu Elgon, or Elgoi, north of Mumia's, which I found to have an altitude of 14,200 feet, with a probable error of 20 feet. This confirms the result of Lieut.-Colonel Macdonald in 1892, when the Uganda railway survey, no doubt giving round numbers, gave it a height of 14,000 feet.

I will now draw your attention to two mountains of considerable height which have been called by various names, and to one of which existence even has been denied by a distinguished geologist. They are vaguely marked on most maps as the "Aberdare range," although they have more than one excellent native name of their own. Sattima rises to a height of 13,390 feet, whilst Kinangop, or Donyu Ronyu, is 12,920 feet above the sea. ‡ It seems hard on two such giants that they should have been ignored; but, although I saw and observed them many times, they are often sulky, hiding themselves in cloud for a month at a time, and from many places near to them are always hidden by intervening hills.

My determination for the height of the Victoria Nyanza was 3775 feet, which again corroborated the railway survey result of 3820 feet.

Concurrently with my trigonometrical and astronomical work, I carried on a plane-table survey on a scale of about 2 miles to the inch, which I had the opportunity of checking many times. As I could not work out my triangulation until afterwards, I had to work my plane-table independently from sheet to sheet. I began each sheet by

* As follows: $\frac{r''}{c''} = 0.065, 0.059, 0.060, 0.058, 0.060, 0.063, 0.066, 0.076, 0.075, 0.077, 0.079, 0.088, 0.091, 0.093$, where r'' = angular refraction correction in seconds, c'' = distance in seconds of arc.

† Lat. $0^{\circ} 9' 13''$ S., long. $37^{\circ} 18' 37''$ E.; height, 17,180 feet.

‡ Sattima, lat. $0^{\circ} 18' 53''$ S., long. $36^{\circ} 37' 38''$ E.; Kinangop, lat. $0^{\circ} 37' 48''$ S., long. $36^{\circ} 42' 29''$.

transferring two points only, which I used as a base, so that each sheet is consistent with itself, and when re-drawn on the triangulated points most of the error disappears. I have used the Geographical Society's system of spelling throughout. I also, for purposes of reference, started a diagram of triangulation in the field on a scale of 8 miles to the inch, which saved me much labour in arriving at first approximations, forming a useful check and helping to identify distant mountains.

A good deal has appeared in the papers lately about the change of route which has been adopted for the Uganda railway, and perhaps a few remarks on the subject would not be out of place. A glance at the map will show that the originally proposed route by Eldoma ravine, Mumia's, and Port Victoria went a very long way round, and that, if a way could be found striking straight for the lake from Lake Nakuru, much distance would be saved. Captain Sclater was tied down by orders to take the road by Eldoma ravine and Mumia's; but although he was not able to see all the country, he expected that the direct route would prove easier. Whilst I was surveying in that part from various lofty hills, I saw very nearly all the country concerned, and was convinced that there lay the best route for the railway. I believe I was the first to get a fair map of the district, and our representations convinced Mr. Whitehouse, the chief engineer of the Uganda railway, that the route, which will save some half-million sterling, was worth a detailed survey. It is not generally known that Lieut.-Colonel Macdonald in '93 intended to return by this route, but was prevented by adverse circumstances.

With the exception that I obtained occasional assistance in time-taking for astronomical sights from other gentlemen, I did the whole of this survey unaided, nearly all of it in my spare time. It cost under £100. It will shortly be published by the Intelligence Department, War Office, on a scale of 1 : 250,000, or nearly 4 miles to the inch, with other work incorporated with it.

I cannot close a paper on East Africa without acknowledging heartily the hospitality and unfailing kindness of the various Government officials stationed in the Uganda and Coast Protectorate whom I have met, and wishing them every success in the somewhat lonely life which they have selected.

APPENDIX I.

INDIAN SYSTEM OF COMPUTATION.

'The Auxiliary Tables to facilitate the Calculations of the Indian Survey,' 1887, is the work employed. The formulæ used in computing are given as "Alternative Method in Secondary Triangulation," pp. 69 *et seq.*, and are more than sufficiently accurate for the instruments that I employed.

The following symbols are employed :—

- λ = latitude of point A.
 L = longitude „
 A = azimuth of B from A, measured from south clockwise.
 $\lambda + \Delta\lambda$ = latitude of B.
 $L + \Delta L$ = longitude of B.
 $\pi + A + \Delta A$ = azimuth of A from B.
 c = distance AB.
 ρ = radius of curvature of meridian.
 ν = normal, terminated at minor axis.

$$\text{Then } \Delta\lambda = -\frac{c}{\rho} \cos\left(A + \frac{\Delta A}{2}\right) \operatorname{cosec} 1'' \dots (1)$$

$$\Delta L = -\frac{c}{r} \frac{\sin\left(A + \frac{\Delta A}{2}\right)}{\cos\left(\lambda + \frac{\Delta\lambda}{2}\right)} \operatorname{cosec} 1'' \dots (2)$$

$$\frac{\Delta A}{2} = \frac{\Delta L}{2} \sin\left(\lambda + \frac{\Delta\lambda}{2}\right) \dots (3)$$

$$\log \frac{\operatorname{cosec} 1''}{\rho} = \operatorname{colog} (\text{Table XXVI.})$$

$$\text{and } \log \frac{\operatorname{cosec} 1''}{\nu \cos\left(\lambda + \frac{\Delta\lambda}{2}\right)} = \operatorname{colog} (\text{Table XXVII.})$$

These equations lead to very simple computations. I allowed for spherical excess in the larger triangles, although it was hardly worth while using Table IV. for the purpose. The computations for heights are given on pp. 24 to 30. I may remark that the coefficient of refraction alluded to in the text is the quantity $\frac{r''}{c'}$, where r'' = refraction in vertical angle at A or B in seconds, and c' = contained arc of Earth's surface between A and B in seconds.

APPENDIX II.

A method of finding the most probable position of a station from a round of angles to points of known position when the azimuth of all points is only approximately known from a plane-table resection, applying the theory of least squares.

I describe the operations. I do not propose to prove the method.

1. Choose a suitable point (A) of the known points, such that the line joining it to your station (called X) is a common side to all the triangles having XA and each of the other known points at the angles, and such that the triangles are all of fair shape.

2. Then the problem is solved when you determine distance XA and azimuth θ of X from A.

3. Take approximate azimuth θ_1 from plane-table, and solve triangle XAB (BCD . . . being other known points). This gives a value α_1 for distance XA. Recompute triangle XAB with value for azimuth a little greater and a little less than θ_1 , which we call θ_2 and θ_3 . This will give new values α_2 , α_3 for distance XA. Similarly, compute the triangles XAC, XAD, etc., with the azimuths θ_1 , θ_2 , θ_3 , giving values β_1 , β_2 , β_3 , γ_1 , γ_2 , γ_3 , etc., for distance XA.

4. Plot as abscissæ on a suitable scale the azimuths $\theta_1, \theta_2, \theta_3$. Plot also on a suitable scale as ordinates the lengths $a_1, a_2, a_3, \beta_1, \beta_2, \beta_3$, etc. (It is usually more convenient to plot the log distances, which, within the limits required for this purpose, are proportional to the lengths. Then join a_1, a_2 , and a_3 ; this line represents the locus where the ordinates are length XA, abscissæ azimuth θ . Similarly, join $\beta_1, \beta_2, \beta_3$, etc. Find a line of mean values (ordinates being means of respective ordinates of lines a_1, a_2, a_3 , etc.). θ is treated as Independent variable.

5. By inspection observe about where the line of mean values differs least from lines a_1, a_2, a_3 , etc. Near this point draw several ordinates. On each of these ordinates find the square root of the sum of the squares of the errors of the lines a_1, a_2, a_3 , etc., on the line of mean value. (This can easily be done with a pair of compasses.) Plot on each ordinate below the axis of azimuths this length. Join the points so found by a curve, which is the locus of square root of sum of squares of the apparent errors on the mean line. The horizontal tangent to this curve touches it at the point P. Draw the ordinate PQ, cutting line of mean values in the point Q. Then the ordinate and abscissæ of point Q are respectively the distance XA and the azimuth θ when the square root of the sum of the squares of the apparent errors is a minimum. In other words, we have found the most probable distance XA and azimuth θ .

The above process can be repeated on a larger scale, if necessary. This process has the objection that it gives greater weight to one of the points A than it does to any of the others, as that point has been combined with each of the others. This method was only looked upon as giving a better value for my starting-point than I could hope to get with a small-scale plane-table. The value of azimuth obtained at Morendat was the one finally adopted. If the lines a_1, a_2, a_3 , and $\beta_1, \beta_2, \beta_3$, etc., are parallel, the problem is indeterminate, A, B, C, D, . . . and X all lying on one circle.

APPENDIX III.

SLIDE-RULE METHOD OF COMPUTING HEIGHTS.

In surveying operations it is constantly required to find out the difference in height between two hills approximately. For minor points on a small-scale map, you do not wish to go through the labour of the rigid methods. The following method I have found to give results within about 20 feet of the rigid method up to distances of about 20 miles and angles of $1^\circ 20'$, within which most of such problems would come. On Cary's ordinary boxwood slide-rule is found a logarithmic scale twice repeated for numbers, and a logarithmic scale of sines (the difference between sines and tangents on such a scale is imperceptible below 3°), from $40'$ to 90° . If the scale of sines be enlarged to nearly twice the length, we reach log sine $30''$ on the left hand of the scale. To use this in the ordinary way, the scale of numbers has to be repeated five times. The problem is now in this form: Given distance (plain surface) between two points in feet and vertical angle, we get answer difference of height in feet.

But, working with a small-scale plane-table, it is much more convenient to measure off the distance in miles or geographical miles; so that, using such a slide-rule in the ordinary way, you would have to measure off distance in miles, multiply out into feet, and then proceed, using the ordinary zero of $\sin 90^\circ$, or a special scale of feet would be required on each sheet. This complication may be avoided by shifting your zero a suitable distance towards the left on the scale of

sines. The zero for geographical miles comes at $\log \sin 5' 38''$ about. We can now cut off all the scale of $\log$ sines to the right of $1^\circ 10'$, and, using scale of numbers of ordinary size, we get a compact instrument. From this we can directly solve the problem, given (plain surface) distance in geographical miles, vertical angle between $30''$ and $1^\circ 10''$, to find height in feet.

Now, since the correction for curvature and refraction in arc is a nearly constant ratio of the contained arc or distance, we can place a mark "K" a suitable distance from our zero, and when the zero is placed opposite the distance, "K" will be opposite the angular correction to the vertical angle. If angles of elevation be taken as positive, and of depression as negative, we have "K" always positive.

Example.—Distance A to B = $12\frac{1}{2}$ geographical miles; vertical angle = $-15' 30''$.

Place zero opposite $12\frac{1}{2}$, then K* is opposite $5\cdot4$. Then $5\cdot4 = 5' 24'' =$ correction.

$$\text{Vertical angle} = -15' 30''$$

$$\text{Correction} = + 5' 24''$$

$$\text{Corrected angle} = -10' 6''$$

Opposite $10' 6''$ (without shifting slide-rule) will be found 151. *Answer*, B is 151 feet below A.

The above can all be done easily in the head.

APPENDIX IV.

PLOTTING.

I plotted my graticules in the ordinary way from the tables given in Auxiliary Tables Indian Survey. But I soon found that the convergency of the meridians was so small for latitudes of under $2^\circ 30'$ that I neglected it altogether, simply using rectangular co-ordinates of the proper length. Such plotting errors are less than that due to the stretch of the paper.

TABLE I.
MAIN TRIANGULATION.

Station.	Latitude.			East Longitude.			Height.
	°	'	"	°	'	"	
Mbinzau	2	21	12·7 S.	37	55	6·8	4,590
Imali	2	3	47·5 „	37	22	37·5	6,007
Kiu	1	46	48·9 „	37	15	0·2	6,694
Lamwia	1	25	24·4 „	36	38	18·1	8,177
Longonot	0	55	7·0 „	36	26	47·8	9,224
Kijabi	0	54	39·9 „	36	32	42·1	8,870
Bura	0	38	13·2 „	36	15	51·4	8,857
Morendat	0	40	19·9 „	36	23	25·6	6,362
Ngorika	0	18	24·5 „	36	12	58·0	7,655
Loldiani	0	6	47·7 „	35	43	32·2	10,002
Legisianan	0	1	1·0 N.	36	3	41	6,270
Ravine station... ..	0	2	58·7 „	35	43	59·3	7,239
Wath	0	2	36·2 „	35	31	30·3	9,586
Kuyu	0	1	24·0 „	35	3	51	6,859
Kepur	0	5	44·7 „	35	9	52·4	7,298
Kiptoiyu	0	11	34·5 „	34	59	2·8	6,620
Divali	0	29	26·5 „	34	36	59·4	5,080
Mumia's (east gate of fort)	0	20	14·1 „	34	28	46·3	4,425

* K is computed for a mean coefficient of refraction of 0·075.

TABLE II.

INTERSECTED POINTS ON WHICH MAIN TRIANGULATION PARTLY DEPENDS.

No. of triangles solved.	No. of vertical angles solved.	Name.	Latitude.	East Longitude.	Height.
			° ' "	° ' "	feet.
1	3	Loldiani foothill	0 9 59.3 S.	35 43 4.3	8,970
3	4	Kamasia ...	0 10 31.6 N.	35 41 37.9	9,264
1	3	Bura 1 ...	0 12 54.0 S.	35 41 8.2	9,019
2	4	Uzoma ...	0 23 18.2 S.	34 29 34.1	5,795
1	3	Tenderit or Langai	0 4 45.4 S.	35 21 24.0	8,809
1	3	Alagabeit C ...	0 24 55.8 N.	35 6 16.8	6,911
1	3	Tobolwa's stone	0 23 27.9 N.	34 58 26.5	7,170
2	5	Elgon summit ...	1 6 1.6 N.	34 34 15.5	14,197

TABLE III.

INTERSECTED POINTS.

Computed from		Name.	Latitude.	East longitude.	Height.
No. of triangles.	No. of vertical angles.				
			° ' "	° ' "	feet.
4	6	Kenia ...	0 9 13.1 S.	37 18 37.3	17,184
3	7	{Kinangop, or Don- yu Ronyu}	0 37 48.4 S.	36 42 29.2	12,920
3	3	Suswa ...	1 10 40 S.	36 20 52	7,840
2	2	Sangara ...	0 31 17 N.	34 36 8	5,272
2	3	Im. 1 ...	2 42 17 S.	36 42 52	8,730
2	2	Rock peak ...	2 8 34 S.	37 22 48	5,773
2	2	Mb. 2 ...	2 30 1 S.	36 45 1	8,410
2	3	Meru ...	3 15 9.5 S.	36 44 59	15,122
2	3	Bisil ...	2 8 28.5 S.	36 45 22	7,056
2	2	Mendatani ...	2 8 9 S.	37 14 26	6,062
2	2	Mbuzya ...	2 1 0 S.	37 10 18	5,725
2	2	Chamatha ...	1 52 26 S.	37 25 53	6,265
2	2	Single-tree hill	1 55 56 S.	37 26 40	6,011
2	2	Nzowi ...	1 55 13.5 S.	37 32 52	6,069
2	2	Mb. 3 ...	2 13 22 S.	36 52 53	6,954
2	2	Im. 4 ...	2 12 19 S.	36 51 54	6,946
2	2	Im. 5 ...	2 11 0 S.	36 50 19	6,790
2	2	Wami ...	1 38 46 S.	37 7 56	6,386
2	2	Malili ...	1 45 2 S.	37 14 49	6,155
2	2	{Highest just north of Machako's}	1 29 10 S.	37 17 31	6,978
2	3	Sattima highest	0 18 53 S.	36 37 38	13,391
2	2	Lam. 12 ...	0 53 19 S.	36 16 6	8,073
2	2	Lam. 14 ...	0 51 36 S.	36 19 23	7,768
2	2	Bura West ...	0 39 4 S.	36 11 10	9,374
2	2	Bura central α ...	0 38 23 S.	36 14 8	9,433
2	2	Kij 4 ...	0 31 1 S.	36 16 32	7,072
2	2	Eldalat ...	0 3 31 S.	35 49 43	8,019
2	2	Kinangop 1 ...	0 33 27 S.	36 40 9	11,216
2	2	Kinangop 2 ...	0 34 57 S.	36 40 49	11,420
2	2	Bura 5 ...	0 40 23 N.	35 50 26	8,323
2	3	Ngorika 10 B ...	1 2 40 N.	35 30 36	10,360
2	2	Loldiani 3 ...	0 37 4 S.	34 8 4	7,400
2	2	Loldiani 1 B ...	0 31 17 S.	34 12 39	6,032
2	2	Uzoma B... ...	0 22 19 S.	34 29 32	5,492
2	2	Elgon D ...	1 7 28 N.	34 35 46	12,880

Computed from		Name.	Latitude.	East longitude.	Height.
No. of triangles.	No. of vertical angles.				
2	2	{ Elgon west spur, main summit }	0 54 28 N.	34 24 7	feet. 7,835
2	2	{ Elgon west spur, cliff summit }	0 54 56 N.	34 22 38	7,716
2	2	Elgon B ...	1 7 13 N.	34 31 23	14,080
2	3	Elgon C ...	1 6 14 N.	34 33 18	14,000
2	4	Gamoriongo C ...	1 3 37 N.	35 24 30	10,312
2	2	Alagabeit highest	0 24 54 N.	35 5 24	7,218
2	2	Alagabeit B ...	0 24 45 N.	35 4 42	7,051
1	1	Kipt 5 ...	0 21 18 N.	34 49 45	5,742
1	1	Kipt 6 ...	0 27 42 N.	34 47 50	5,598
1	2	Bura central B ...	0 38 15 S.	36 13 58	9,413
1	2	{ Point on Victoria lake, Ugubwibay }	0 16 43 S.	34 47 9	3,775
1	2	Sergoit ...	0 38 37 N.	35 23 23	7,910

TABLE IV.

MINOR INTERSECTED POINTS. *Positions* OBTAINED BY PLOTTING AZIMUTHS OR FROM PLANE-TABLE; *Heights*, BY SLIDE-RULE METHOD.

Number of vertical angles solved.	Name.	Latitude.	East Longitude.	Height.
		° ' "	° ' "	
2	Lake Naivasha ...	—	—	feet. 6312
2	{ Top of half-transome, south end Morendat bridge }	—	—	6328
2	Subugo-Kij 8 ...	0 22 10 S.	36 16 30	8502
2	Lesser Sattima ...	0 25 40 S.	36 32 20	11,174
2	Bura, 6 ...	0 32 0 N.	35 47 15	7,695
2	Loldiani, 1 ...	0 30 45 S.	34 11 55	6,190
2	Mwoititi ...	0 4 1 S.	35 27 33	8,960
2	Southern Kiu ...	1 57 5 S.	37 19 40	5,720
2	Woody top ...	1 59 5 S.	37 28 15	5,561
2	Rhino peak ...	1 50 35 S.	37 30 8	6,072
2	Donyu Sabuk ...	1 8 35 S.	37 15 34	7,137
2	Lukenia ...	1 29 13 S.	37 4 8	6,142
2	Knobble I. ...	1 25 50 S.	37 3 10	5,881
2	Knobble II. ...	1 32 42 S.	37 8 0	5,964
2	Lam 17 ...	1 51 13 S.	35 57 13	7,600
2	Lam 11 ...	2 10 5 S.	35 56 32	6,580
2	Machako's hill (south) ...	1 33 0 S.	37 16 36	6,590
2	Kiket 1 ...	1 47 45 S.	37 21 42	6,700
2	Kiket 2 ...	1 50 7 S.	37 25 35	6,650
2	Wai ...	0 41 10 N.	34 10 44	4,970
2	Samia highest ...	0 17 57 N.	34 9 19	5,280
2	Nakuru lake ...			5,845
1	Elmuteita lake ...			5,860
1	Coll to south-west of Loldiani...			8,500
1	{ Lowest dip in Mau heights to northward of Loldiani }			8,850
2	Likipya 1 ...	NOTE.—For these latitude and longitude were not taken. Distances for computing height were taken from plane-table sheets.		7,520
2	Likipya 2 ...			8,240
2	Likipya 3 ...			8,880
1	Kepur 1 ...			5,640
1	Kepur 2 ...			5,000
1	Plain at base of Kepur 2 ...			4,620
1	Kepur 3 ...			5,250
1	Kepur 4 ...			4,840
1	Plain at base of Kepur 4 ...			4,400

ROAD MAKING AND SURVEYING IN BRITISH EAST AFRICA

BY CAPTAIN G. E. SMITH, R. E.

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