becomes almost appalling. Our ideas of this region were refreshed this year by Mr. Roosevelt, and I think we must have been struck by the similarity in many respects in the descriptions of the rivers given us to-night with that Mr. Roosevelt gave us in his lecture on the River of Doubt, which we can now read at greater length in the very interesting volume he has just presented to our Society. It seems to be a country engrossing for the zoologist. Mr. Roosevelt's book is full of the extraordinary and interesting animals he came across. But if it is a paradise for the zoologist, it seems to be still more so for the entomologist, though the ordinary traveller may not regard it in the same light. We can hardly hope that the boundary now laid down, which I have no doubt will prove an excellent boundary between the two states, will fulfil one requirement which our professors suggested a week ago. It is hardly likely to be a meeting-place of nations, but as a dividing-place between nations, which after all has been hitherto the idea of a boundary, it appears to be admirably suited. It is a source of pride to ourselves, to our Survey officers, and to this Society, that Englishmen should be selected as the best fitted to do this sort of work for other countries. We have all listened to Captain Edwards's lecture with the greatest interest, and have got many new impressions from it. I will now move a vote of thanks to him, which I am sure you will accord unanimously.

SIR AUREL STEIN'S EXPEDITION IN CENTRAL ASIA.*

As soon as a short halt in the Tun-huang oasis had allowed men and animals to recover from our trying winter campaign in the Lop-nor desert, I started by April 2 for the explorations planned eastwards. Their objectives lay mainly in the deserts which fringe on the south and east the vast region of barren hills known as the Pei-shan Gobi. The distances to be covered were great, and short the available season before increasing heat would stop work on waterless ground. So but little time could be spared for my renewed visit to the cave temples of the "Thousand Buddhas" near Tun-huang, which in 1907 had yielded so much antiquarian and artistic spoil. But rapid as my visit had to be, it proved once more fruitful.

Ever since my first discovery in 1907 of the ancient Chinese *Limes* to the west and north of Tun-huang, I had been anxious to follow up its line as far as possible eastward, and to explore whatever ruins might have survived along it. The work was successfully started, when, after striking across a difficult belt of salt marshes, we came upon the ancient border wall halfway between Tun-huang and An-hsi. From there we were able to follow its line for close on 250 miles eastwards. Along almost the whole of this distance the wall, with its watch-towers and small military stations, had been built across what already in ancient times was absolutely sterile desert. The immunity from human interference thus assured had helped greatly to preserve its remains; but the wall owed even more to its remarkable method of construction. Built of carefully

* Communication from Sir Aurel Stein, K.C.I.E., PH.D., D.SC., dated Turfan, November 22, 1914. See *Geographical Journal*, vol. **44**, p. 69.

secured fascines of reeds or brushwood, with layers of clay or gravel between them, the wall was specially adapted to withstand that most destructive of natural forces in this region—slow grinding, but relentless, wind-erosion. Even where the watch-towers, once massively built in bricks or stamped clay, had been reduced to shapeless low mounds, difficult to recognize from a distance, the direction of the wall still clearly revealed itself, stretching away in characteristic straight line across wastes of gravel or drift-sand.

Where the *Limes* ran parallel to the deep-cut bed of the Su-lo Ho much of the ground it crossed consists of bare riverine loess, and in this the erosive force of the winds, blowing here with exceptional violence mainly from the north-east, could assert itself to the full. But even where it had succeeded in completely effacing all structural features, there remained on the wind-worn surface clear evidence, in the shape of pottery, coins, metal fragments, and other hard *débris*, enabling us to determine with accuracy the position of the posts once guarding the border.

Once beyond the sharp bend made by the Su-lo Ho valley southward, the line followed by the *Limes* approached closer and closer to the foot of the Pei-shan, taking us into ground which had so far remained wholly unsurveyed. The physical difficulties met became increasingly greater owing to the distances separating the long-forgotten border from the nearest places with water. But there was reward also in the ample finds of ancient records on wood, of furniture and implements of all sorts which our excavations brought to light at the ruined stations. Conclusive archæological evidence shows that all these had been left behind by the Chinese soldiers who during the first century before and after Christ had kept guard over this most dismal of frontiers. The finds furnish an important addition to the collection of early Chinese records secured during my former explorations west of Tun-huang. Here, too, often the inscribed slips of wood thrown out of some ancient office-room turned up in refuse heaps covered only by a few inches of *débris* or gravel. Their preservation in such conditions clearly demonstrates the remarkable dryness of the climate prevailing here since ancient times. Apart from the uniform barrenness, the topography of the ground crossed by this eastern portion of the *Limes* showed considerable variety, and this helped to bring out still more clearly the skill with which those old Chinese engineers of Han times had managed to adapt their defensive line to different local conditions.

I was more than ever impressed by the remarkable power of sustained administrative effort which the construction of the wall on ground wholly devoid of local resources demanded, when some 30 miles to the north-east of the little oasis of Ying-pên we found the wall boldly carried into what since ancient times must have been a big area of drift sand. Where not completely buried by high dunes, it still rose to close on 15 feet. Obviously the garrisoning and commissariat of this section must have offered special difficulties. It was clearly in order to safeguard an important line of

supplies that a chain of fortified stations was found to extend here southward independently of the wall, but constructed at the same period. It ran in the direction of the big oasis of Suchou, and to this we had to turn ourselves at the beginning of May in order to prepare our next move northward.

My object was to follow the united course of the rivers of Suchou and Kanchou down into Southern Mongolia, and to explore what ancient remains might be found along it and in its terminal delta. Apart from the ruins which the reports of Russian travellers had led me to expect here, I was specially attracted to this ground by the interest attaching to its earliest history. There could be no doubt that this region of the Etsin-gol, as the river is known to the Mongols, had formed part of the wide dominions held by those earliest nomadic masters of Kansu, the "Great Yüeh-chi," or Indo-Scythians and the Huns, whose successive migrations westwards so deeply affected the destinies of Central Asia, as well as of India and the West.

Provided by the Suchou Taotai with a recommendation to the chief of the Torgut Mongols who now graze on the lower banks of the Etsin-gol, I started by May 10 northward. While Rai Bahadur Lal Singh moved to the last Chinese settlement, the oasis of Mao-mei, by the hitherto unsurveyed route along the river Kanchou, where it breaks through the westernmost hill range of the Alashan, I followed the more direct track by the river Suchou. This offered me a chance of once more approaching the area where before we had lost the line of the ancient frontier amidst high dunes. By a reconnaissance pushed into the desert north-west of the Chinta oasis, I succeeded once more in discovering the *Limes* where it emerged on less impracticable ground near the south-eastern extremity of the Pei-shan, and subsequently we tracked it right through to the north of the oasis of Mao-mei.

The course of the river Etsina, affording water and grazing, must always have served as a main route for raids and invasions directed from the Mongolian steppes against the westernmost Kansu oases and the great natural highway which leads through them connecting China with Central Asia. So it could not surprise me to find the point where this route of invasion cuts through the ancient border, guarded by ruined forts of imposing size and unmistakable antiquity. One built with clay walls of exceptional strength curiously recalled the ancient frontier station of the "Jade Gate," famous in Chinese history, and previously identified by me on the Tun-huang border. There could be no doubt that the *Limes* had crossed the river Etsina a short distance to the north of the oasis of Mao-mei, and thence continued eastwards. But when we came back in June from the Etsina delta, the heat of the season had become already too great to permit of continuing the search into the waterless desert eastwards.

Moving north in long marches we followed the sandy bed of the Etsin-gol, in places nearly a mile wide, but absolutely dry at that season. Only in wells dug in places near the banks could water be found. After passing

a rocky spur jutting out from the eastermost Pei-shan, some 90 miles below Mao-mei, the river spreads out in a delta which extends for over 110 miles to the north and terminates in a series of salt lakes and marshes. A succession of low-water seasons had caused these to dry up for the most part. The conditions observed in this delta interested me greatly, as they strikingly illustrated what the ancient Lou-lan delta north of the extant Lop-nor marshes looked like before its final desiccation. Here, too, along beds left dry for long years many of the wild poplars prevailing in the narrow belts of riverine jungle were already dead or dying. The wide stretches of ground between the several beds were either absolutely bare or showed but scant vegetation. The chief of the two hundred odd Mongol families established in the Etsin-gol delta sadly complained of the increasing difficulties caused by inadequate grazing.

Limited as are the resources offered by this extensive riverine tract, it was yet easy to realize their importance for those, whether armed host or traders, who would make the long journey from the heart of Mongolia in the north to the Kansu oases. In this respect, too, there was a striking analogy to the ancient Lou-lan delta, without which the earliest and most direct route into the Tarim basin could not have been opened for Chinese expansion westwards. This analogy impressed itself still further upon me when I proceeded to examine the ruined town of Khara-khoto, which Colonel Kozloff, during his expedition of 1908-09, had been the first European to visit. Its position and remains clearly proved that it could be no other than Marco Polo's "City of Etzina." Of this the great Venetian traveller tells us that it lay a twelve days' ride from the city of Kanchou "towards the north on the verge of the desert; it belongs to the Province of Tangut." Travellers bound for Karakoram, the old Mongol capital, had to lay in here victuals for forty days in order to cross the great "desert which extends forty days' journey to the north, and on which you meet with no habitation nor baiting place." The position thus indicated corresponds exactly to that of Kharakhoto. Though the town had probably suffered considerably when Chingiz Khan's Mongol host first invaded and conquered Kansu from this side about A.D. 1226, there was ample antiquarian evidence to show that it continued to be inhabited down to the fourteenth century. But like the agricultural settlement for which it had served as the local centre and of which we traced extensive remains to the east and north-east, the town must have seen its most flourishing times under Tangut or Hsi-hsia rule, from the beginning of the eleventh century down to the Mongol conquest.

To this period belonged most of the Buddhist shrines and memorial stupas which filled a great portion of the ruined town and were conspicuous also outside it. In one of the latter Colonel Kozloff had made his great find of Buddhist texts and paintings. But this, as a systematic search soon proved, had not exhausted the archæological riches of the site. Careful clearing of the *débris* of stupas and temples brought to light

abundant remains of Buddhist manuscripts and prints, both in the little-known old Tangut script and Tibetan, besides many fine stucco relievos and frescoes. From the large refuse heaps of the town we recovered plenty of miscellaneous records on paper in Chinese, Tangut and Uigur, also many interesting remains of pottery and household utensils. Finds of coins, ornaments in metal and stone, etc., were abundant, particularly on wind-eroded ground.

Everything pointed to the conclusion that the abandonment of the settlement must have been caused by difficulties about maintaining irrigation. The dry river channel which passes Khara-khoto lies some 7 miles to the east of the nearest branch still receiving water, and the old canals we traced leading to the abandoned farms eastwards are removed considerably further. Whether this failure of irrigation was due to desiccation in the Etsin-gol delta or to a change in the river course at canal-head with which the settlement was unable to cope, could not be determined. But so much seemed clear that the water-supply now reaching the delta during a few months of summer would no longer suffice to assure adequate irrigation for the once cultivated area.

Rapidly increasing heat had rendered work at these desert sites very trying both for the men and our camels, upon which we depended for the transport of water. So I was glad when the completion of our task allowed me to send the camels for a much-needed summer holiday in the Kongurche hills north-eastward, and to move myself south to the foot of the Nan-shan. For part of the journey we were able to follow a new route which took us through hitherto unsurveyed portions of the desert hills to the east and north of the river Kanchou. In spite of serious fatigues, Kanchou was safely reached before the close of June. A short halt in that large oasis enabled me to make all arrangements for new survey work I had planned in the Central Nan-shan. Its object was to extend the mapping done in 1907, in the mountains near the sources of the rivers Su-lo Ho and Suchou, by accurate surveys of the high ranges further east which enclose the river Kanchou headwaters.

Great difficulties were encountered about transport owing to the reluctance of the Chinese to venture far into those mountains. But fortunately I found an old friend in the Chinese general commanding at Kanchou, and his opportune help allowed us to set out by the first week of July. The route followed during the first marches acquainted me with interesting Buddhist cave temples, and other remains dating from Sung times, near Nan-kou-chêng at the foot of the mountains. There, too, we struck a dividing line of distinct geographical interest. While to the west of it cultivation, whether in the plain or along the foot of the mountains, is possible only by means of irrigation, we now came upon Loess slopes and big alluvial fans which rainfall alone suffices to make fertile. This marked change in climatic conditions appropriately brought home the fact that we were now nearing the watershed of the Pacific

drainage area, and the eastern edge of that part of Kansu which may justly be considered a Central-Asian border land.

We had ascended to where the easternmost feeder of the river Kan-chou rises among snow-clad ranges, and were making our way westwards over high alpine grazing grounds, when I met with a serious riding accident. Fortunately the arrangements already made allowed R. B. Lal Singh, my ever-energetic surveyor, to carry through all the topographical tasks I had planned, and no time was lost in our programme. When after some weeks my injured leg had recovered from the worst effects of the accident, I managed to get myself carried down to Kanchou. Then by the third week of August, I set out for the long journey which was to take me back to Turkestan for the work of the autumn and winter. On reaching Mao-mei by a new route, I was rejoined by Lal Singh, who by exceptional efforts had succeeded in extending our Nan-shan surveys eastwards over an area quite as large as that mapped in 1907.

On September 2, we started to cross the desert area occupied by the ranges of the Pei-shan where its width is greatest, in the direction from south-east to north-west. The routes we followed for close on 500 miles had never been surveyed, and only at one point did they touch ground previously visited by Russian travellers. Wherever possible we moved in two parties and by different routes, thus considerably increasing the extent of the area mapped. The scarcity of wells and of grazing caused great difficulties, and we felt them even more owing to the inadequate local knowledge possessed by our Chinese "guides." Only at one place did we encounter a small party of Mongols.

It was a great relief when after nearly four weeks of continuous travel we had safely crossed the last barren hill range, without a single animal's loss. It proved an easternmost extension of the Tien-shan system, and beyond it we could descend to Jungarian ground at the foot of the Karlik-tagh. These extensive plane-table surveys, supported here as elsewhere by many careful height observations with mercurial barometer and clinometer, will throw fresh light on the morphology of the Pei-shan ranges. In addition this journey has served to acquaint me with the peculiar physical conditions of a region through which many of the great historical migrations westwards, since those of the Indo-Scythians and Huns, must have passed.

Interest of a similar character attached to the rapid journey which subsequently carried me during October along the north foot of the Tien-shan range to Barkul and Guchen (Ku-ch'êng-tzu). These territories, favoured by a climate less dry and possessed of abundant grazing grounds, have often played an important part in the history of Eastern Turkestan, and their physical and ethnic conditions differ greatly from those of the Tarim basin. The opportunity of familiarizing myself with this ground was hence a decided advantage. I was also able to survey, near Jimasa, west of Guchen, extensive remains marking the site of an ancient capital

of this region, which under the names of Chin-man and Pei-ting often figures in the Chinese historical records from Han to T'ang times.

From there I crossed the Bogdo-ula range, a portion of the Tien-shan rising to numerous snowy peaks, by a high pass hitherto unsurveyed to the deeply depressed basin of Turfan. There ruined sites of Buddhist times are abundant. A preliminary survey has shown me that their remains, though repeatedly visited by previous expeditions, and owing to their easy access exploited also by villagers burrowing for antiques, still offer scope for systematic excavations. To these I propose to devote the next few months, while my surveyors will find ample work in mapping the extensive and little-known desert ranges of the Kuruk-tagh between the Turfan and Lop-nor depressions.

PLANE-TABLE TRIANGULATION FROM ONE STATION ONLY.

By E. A. REEVES.

THE following is a short description of an attachment I have recently fitted to a plane-table alidade for rapid graphic triangulation and fixing the distance of points from one station only, with an example of work done.

Let 1, 2, 3, 4 (Fig. 1) be a plane-table over a station at A; B and C, distant points in the country, of which B is much nearer to A than C. To determine the distance and position of C by the ordinary method of plane-tabling, the distance from A to B is measured on the ground and set off to scale on the plane-table, on which it is represented by A*b*. AB now serves as a base, and after drawing rays from A towards B and C, the surveyor moves his plane-table to B, orients, and again draws a ray towards C, the intersection of which ray with that drawn towards the same point from A gives the position and distance of C. *c* represents this point on the plane-table.

However, in order to carry out this operation it is necessary for the surveyor to move his plane-table from one end of the base to the other; and if distant points such as C could be fixed and a graphic triangulation carried out from one station only, without moving the plane-table, it would frequently be a great advantage, specially in country difficult for travelling.

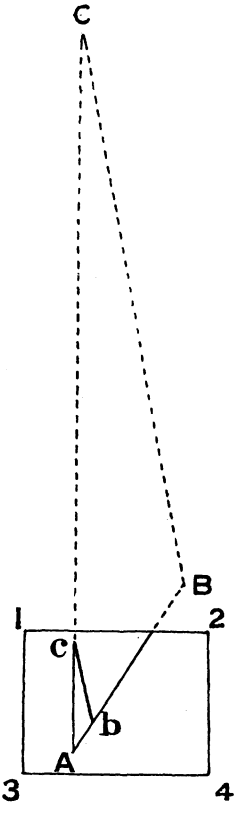

FIG. 1.

The attachment here described provides means of doing this; and it is not limited to short distances as is the case with ordinary tacheometers and range-finders, but can be