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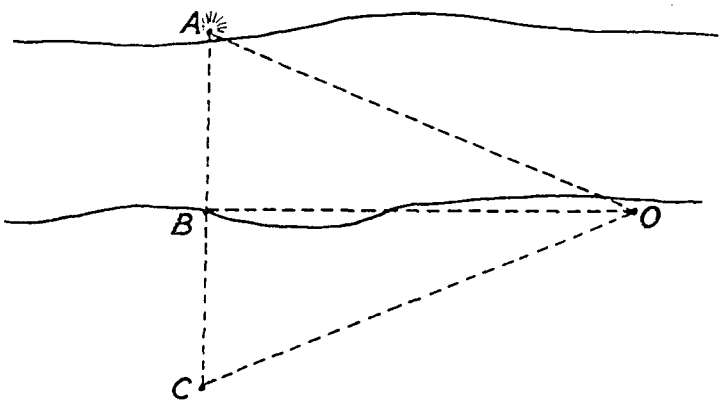
Authors alone are responsible for the statements made and the opinions expressed in their papers.

A RAPID METHOD OF MEASURING GAPS UP TO 75 FEET WITHOUT APPARATUS OF ANY SORT.

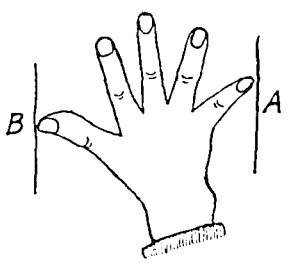
By 2ND LIEUT. R. C. CHRISTIE, 80TH (FIELD) CO., R.E.

CHOOSE an object A on the far bank (a tuft of grass will often be enough), place a stick opposite it at B. Place a man C in line with AB, so that BC is about equal to the width of the river.



The observer O places himself at a convenient distance, so that the angle ABO=90°. To do this it is quite sufficient to estimate when A and C are equally distant from him.

From O the exact position of C is obtained by spanning with the hand.



Holding the hand at arm's length—back towards one—spread the fingers until the thumb just touches B, and the little finger, A (see *Fig.*).

Now move the arm towards BC, and move C until BC spans the same as AB.

Then BC=AB.

Using the above method I have measured gaps up to 75 ft. quickly, and with an error never exceeding 3 per cent. Beyond that width the advantage of speed and simplicity becomes hampered by the size of the triangle OBC.

Bridge Repairs By Kamerun Expeditionary Force

BRIDGE REPAIRS BY KAMERUN EXPEDITIONARY FORCE.

A ROYAL ENGINEER officer in the Kamerun writes as follows :—

The enclosed photos may be of interest for publication. On their retirement from Duala the Germans cut two spans of the 5-span girder bridge (total length, 1,000 ft.) at Japoma over the river Dibamba, about 11 miles east of Duala.

The centre span was the one presenting most difficulty as regards repair owing to the depth of water (20 ft.) and a 3-knot current.

The repair was carried out by a French Railway Section which joined the Expedition from French Guinea and was placed under the orders of the Chief Engineer.

Piles were driven to support the existing girders in the positions in which they had fallen. Timber trestles were then erected on the upper flange of the dropped portion of the girder, and traffic has been running regularly since the repairs were effected.

RUNNING COSTS OF MOTOR VEHICLES.

LIEUT. ROBERT W. A. BREWER, A.M.INST.C.E., M.I.MECH.E., F.S.E., in the course of a paper on "Running Costs of Motor Vehicles," read before the Society of Engineers recently, stated that the problem before the automobile engineer was to transport persons and goods in a minimum of time and at a minimum cost. The second consideration was, perhaps, the more important, and could be profitably discussed from an engineering standpoint. The main heads under which expenses might be classified were :—

(i.). Fuel cost and consumption.
(ii.). Lubrication systems and consumption of fuel.
(iii.). Wear and maintenance.
(iv.). Tyres.

As regarded fuel cost, it could not be said that a powerful engine was proportionately a greater fuel consumer than a similar one of less power, and the author discussed the factors producing economy in the use of fuel. The question of efficient lubrication was of the highest importance, but little progress had yet been made and further experiments were necessary. Piston friction also required more investigation, the most suitable form and material and the appropriate number of rings for a given type of car being yet undecided; attention was also directed to the problem of piston clearance. In valve mechanism there was little room for improvement, but the transmission losses had not yet been reduced to a minimum.

Gas friction caused loss due to the reduction of the volumetric efficiency of the engine, and efficient carburation played an important part in reducing loss from this cause, while changes of direction of flow should be made as easy as possible. At all diversions of the flow path a sufficiently high wall temperature must be provided to prevent precipitation. It was not so much the quantity of heat as its application at the correct points that was of the highest importance.

The author criticized the usual method of conducting fuel consumption tests, and indicated the importance of using an accelerometer when making such tests. The variation of the power required to drive a car was due largely to wind and rolling resistances. Total car resistance was also influenced by the balance of the wheels, engine parts, and propeller shafts.

SIEGES AND THE DEFENCE OF FORTIFIED PLACES BY THE BRITISH AND INDIAN ARMIES IN THE XIXth CENTURY.

(*Continued*).

By COLONEL SIR EDWARD T. THACKERAY, V.C., K.C.B. (LATE R.E.).

THE SIEGE OF DELHI (*continued*).

The Major-General having communicated to the Chief Engineer his opinion that an assault *de vive force* was not expedient, attention was sedulously given to strengthening the position on the ridge, providing cover for the troops, clearing jungle and brushwood on the slopes, so as to diminish as much as possible the cover for the enemy, and finally to the security of the communications, by the demolition of all the bridges by which the enemy could cross the western Jumna Canal or Nujufghur Jheel Drainage Cut with his artillery.

On the 7th July a detachment of sappers and pioneers destroyed the Shalimar and Badlee Bridges, as well as a third bridge. These bridges had all superstructures of wood on masonry abutments and piers, and the demolitions were effected by the use of small charges sufficient to clear away the masonry retaining the girders, and by the subsequent removal of the latter and the roadway resting on them. The beams were required for use in the Engineer Park, and it was important to save them. On the 8th, the Busaye Bridge, the only remaining work of the kind on the drainage channel within moderate distance of the city, was also destroyed. On the 9th, the remaining bridges between the camp and Alipore were dismantled. On the same day, the Poolchuddun Aqueduct, of which the demolition had previously been only partial, was completely destroyed.

As part of a concerted scheme, apparently, a detachment of the enemy's cavalry charged into the camp on the 9th, and after causing considerable confusion and some loss was repulsed with heavy slaughter. A general attack was also made on the position under cover of a very hot fire from the place. A strong column under Brig.-General Chamberlain advanced through the suburbs, clearing them of the enemy, and driving him into the city. It suffered most severely however, the loss on this day being 228 in killed and wounded, considerably heavier than any other action in which the force had previously been engaged.

The Engineer Brigade was, however, happily strengthened the same day by the arrival of 300 Punjab sappers armed, under the command of Lieut. Gulliver, and 600 pioneers unarmed, under Lieut. H. A. Brownlow. The latter had been formed by the Chief Engineer, on receiving orders to take command of the brigade, by volunteers taken from the workmen employed on the Ganges Canal at Roorkee. Strange to say, these men, who were at once transferred from the peaceful tasks of day labourers to the most dangerous duties of working parties in siege operations, never exhibited a symptom of fear, but worked under the hottest fire like veterans, and were invaluable. The casualties among them were inevitably very numerous, but no instance occurred of their having hesitated to obey any order, whatever its consequences might have been. Lieut. Brownlow brought with him under their escort a large supply of stores of various kinds for the Engineer Park, drawn from the workshops of the Canal Department.

Between the 10th and 14th July active work was carried on in strengthening the right flank of the position. Early in the siege, a lofty mound, evidently a disused brick kiln, had been taken possession of, its crest roughly formed into a battery for three heavy guns, and an approach of easy slope cut along its face. It was called "The General's Mound," from having been a favourite position of Sir Henry Barnard during the many fights of which he was an eye-witness. It was between this mound and a mass of ancient Mahomedan buildings abutting on the Nujufghur Jheel Channel that the enemy's cavalry broke through on the 9th, and it was necessary to make the ground impracticable for horsemen. Strong parapets, deep ditches, and thick abattis of trees and brushwood were carried over all the open spaces; provision was made for placing field guns in battery behind the bank on the right of the mound. The line to the drainage channel was thereby strengthened to be safe against attack.

Part of the ground in front of the Pagoda picquet being wholly unflanked and supplying cover frequently taken advantage of by the enemy, it was determined that a small battery for two field guns should be constructed on the right of Perkins's Mortar Battery, a position commanding the ground in question. There being reason to anticipate another general attack on the right of the position, the battery, for the sake of expedition, was built of sandbags, covered with a screen of gabions. The pioneers completed the work between 3 a.m. and 11 a.m. on the 15th, notwithstanding interruption from the enemy. This battery was called "Taylor's Battery," named after Capt. Taylor.

About sunrise the enemy attacked, as was expected, and the contest continued with variable vigour throughout the day. The position had been gradually so strengthened in all its parts that no

impression could be made upon it. The troops remained quietly under cover of their parapets, and the artillery inflicted heavy loss on the enemy from all the batteries on the right. Scarcely any casualties had occurred until it was determined to move out and drive the enemy from the strong and rugged ground he usually held. This was done, of course, but with some loss, and in the impetuosity of pursuit the column followed the retreating enemy close up to the walls of the city. There they were received with a murderous grape-shot fire, and officers and men fell thick and fast. The commander of this column, Brigadier Chamberlain, was struck down by a dangerous wound, and before the troops could be extricated from their position, 13 officers and 209 men were placed *hors de combat*. The casualties in the Engineer Brigade included three officers, Lieut. J. T. Walker, Bombay Engineers, severely, and Lieuts. Geneste and Perkins slightly, wounded.

The total casualties in the two actions of the 10th and 15th having risen to nearly 500 men, it was necessary to abandon all idea of any active operations against the place from the latter date. Up to that date it had been the personal conviction of the Chief Engineer, duly submitted to the consideration of the Major-General commanding, that the possibilities of success by assault were such as would justify the attempt being made, should the political necessity for it be so great as to warrant very grave risks being accepted. It was no matter of regret to the Chief Engineer that his judgment on this point was never put to the test, it having been held that the risks were greater than the circumstances of the moment would warrant the General in meeting, but from this time his views were entirely in accordance with that conclusion, and thenceforward but one idea regulated the operations of the Engineer Brigade, to prepare, namely, by economy of men and material on the spot, and, by collection of the same from every available point for the breaching of the city walls, and the attack of the place by siege operations, followed by open assault.

On the 16th and 17th, the breastwork at the Pagoda picquet was strengthened, and a traverse constructed, batteries were repaired, and a magazine made for Taylor's Battery. Metcalfe's picquet was strengthened by a ditch in front of the cow-house. On the 18th a party of Major Coke's Corps raised and strengthened the breastwork between Johnson's Battery and the Crow's Nest. At Metcalfe's picquet, an officer and 40 men were employed during the night in endeavouring to ascertain the truth of the supposed existence of an enemy's mine under the stable. The noise of what seemed to be miners at work was distinctly heard, but ceased on our party commencing to drive a shaft in the stall of the stable where the noise was most distinctly heard. On the 19th another desultory attack was made on our right, which continued for some hours. Our men

suffered but little loss while behind their trenches and breastworks; most of those hit being struck by shots from the Subzee-Mundee taking them in reverse. In the afternoon, a column under Brigadier Jones advanced and drove the enemy out of the Subzee-Mundee and Trevelyan Gunge. Lieut. Crozier, of the 75th Regiment, was killed on this occasion. On the 21st and 22nd the rear breastwork at the Metcalfe picquet was completed, very much improving the defences at that part, and placing them in a most satisfactory condition.

On the 25th—26th July, the lines of fire of the centre battery were altered and readjusted, so that one embrasure should bear on the Moree, a second on the Cashmere Bastion, and the third on Ludlow Castle. Lieut. Greathed, with 40 sappers, completed the demolition of the Rohtuk Road Bridge, leaving a gap exceeding 60 ft. in width.

Heavy rain fell on the 27th. The clearance round the Subzee-Mundee post was, however, continued, and the interior defences at the Pagoda picquet were strengthened and completed. On the left front the Flagstaff breastwork was improved. In addition to the above works, the preparation of gabions and fascines in the Engineer Park was continued daily without interruption.

By the 26th July no letters had been received for six weeks, all having been stopped or lost, and reinforcements were still expected. The enemy continued to make attacks on our position three or four times a week. Their average losses on each occasion amounted to some 300 or 400 men killed and wounded. Our position at this time was thoroughly entrenched on all sides, and perfectly secure from the enemy's attacks. About this time some attempts were made to destroy the bridge of boats across the Jumna River near the Selimgurh Fort, by floating down rafts, but without success. At this time we had been seven weeks in front of the city with a force of about 3,000 men, and had to repulse the enemy's sorties, which were sometimes made with a force of 10,000 or 12,000 men. One of the greatest discomforts at this period of the siege was the great plague of flies.

It was usual to watch the enemy's sorties from the batteries on the ridge. They sometimes occupied an hour in issuing from the city—cavalry, artillery, and infantry. The ground between the ridge and the city was very favourable for the enemy, being covered with rocks, trees, and bushes, from behind which they were able to pick off our men.

It may be remembered that the siege took place during the rainy season, so that the troops were continually drenched. The Engineer officers had to take parties of unarmed coolies out at dusk, and to work between the ridge and the city, their work usually consisting of felling trees and bushes, and clearing the ground in front of the

picquets. Attacked by the enemy in the darkness and rain, it was really wonderful how patiently these poor coolies bore their sufferings, and their conduct was a matter of universal admiration. All the troops suffered alike. The officers received a daily tot or ration of rum like the men. Many now suffered from dysentery, and cholera had broken out. The commander of the Delhi Field Force, Sir Henry Barnard, as has been stated, was seized with cholera on the 5th July, and died in a few hours. Sales of effects of officers who had been killed, took place almost daily; a bottle of beer sold for 4 or 5 rupees, and a bottle of brandy for 20 rupees. Capt. A. Taylor was at this time second in command of the Engineers. He had a charmed life. It was his habit to go about alone, sometimes mounted, but more frequently on foot, between the ridge and the city, reconnoitring the enemy's position, and he seemed to have the faculty of dispensing with sleep. On several occasions he succeeded in penetrating, alone and in daylight, through the enemy's outposts, to study the ground on which our operations would have to be conducted.

Although during the sorties that were of almost daily occurrence the fighting generally ranged along the whole of the front of our position, the picquets stationed at the Subzee-Mundee may, perhaps, be awarded the palm for the deadly nature of the combats which they sustained, and for the severity of the fighting. Hand-to-hand combats were of frequent occurrence. On one occasion, during one of these fights, a rebel Sepoy thrust his head through an opening of the wall of the serai. A Goorkha Sepoy below the wall seized him by the hair and chopped off his head with one stroke of his kookree.

The route by which the troops marched from the camp to the ridge before arriving at the latter was much exposed to fire from the enemy's shot and shell throughout the siege. The shot fired from the city which missed the batteries on the ridge just cleared the top of the ridge and fell in the valley beyond. Dead camels, horses, and bullocks lay in every direction in this valley.

It now began to be understood in the camp that the mutineers had broken out into mutiny some days before the time decided upon by the confederation, at the head of whom was the Moolvie of Fyzabad. This is also the view taken by Colonel Malleson in his history of the Indian Mutiny, and he states that the date fixed upon was the 31st May. The punishment at Meerut of the 89 troopers of the 3rd Light Cavalry, who were sentenced by a court-martial to periods of imprisonment varying from six to ten years for refusing to take the greased cartridges, precipitated the Mutiny. It was commonly reported that out of 74 regiments of infantry in Bengal, only five remained staunch. News was received at this time that the Europeans at Agra had been compelled to retire

into the fort, and also of the capitulation of Sir Hugh Wheler, at Cawnpore, and the subsequent massacre of all the Europeans at that station with the exception of Lieuts. Mowbray Thompson and Delafosse, and two privates, who escaped after undergoing wonderful adventures and sufferings. It was frequently believed, and stated both by officers and men at this period of the siege, that death would be preferable to falling into the hands of the rebels.

There were present at the siege two officers who subsequently rose to high rank, Lieut. Roberts (afterwards Commander-in-Chief in India, and Field Marshal Lord Roberts of Kandahar) and Capt. Donald Stewart (afterwards Commander-in-Chief in India, a baronet, and G.C.B.). Lord Roberts was D.-A. Quartermaster-General of Artillery during the siege, was wounded on the 14th July, and his horse was shot under him on the 14th September. Sir Donald Stewart commanded the volunteers serving in the Allygurh District in May and June, 1857, and all communications with the upper provinces having been cut off, he volunteered to carry dispatches from the Governor of the North-West Provinces to the officer commanding at Delhi. On arriving at the camp he was appointed D.-A. Adjutant-General of the Field Force, and served throughout the siege, and afterwards as Assistant Adjutant-General at the Siege and Capture of Lucknow, and in Rohilcund. Among other distinguished officers who were present at the siege were General Sir Henry Norman, G.C.B., Governor of Queensland, who was Adjutant-General after the death of Colonel Chester, killed at the Battle of Badle-ka-Serai, General Sir Charles Reid, G.C.B., who commanded all the advanced posts on the right of the Delhi Ridge, including Hindoo Rao's, the key of the position, during which 26 separate attacks were made, and also a column on the 17th June for the attack of Kissengunge, and the 4th column of assault on the 14th September, being severely wounded on that occasion, General Sir D. Probyn, K.C.B., V.C., who commanded the 2nd Punjab Cavalry, General Sir John Watson, V.C., and many others.

At dawn on the 12th August a column consisting of 350 1st Bengal Fusiliers, 100 2nd Bengal Fusiliers, 100 8th King's Regiment, 100 75th Regiment, 300 Coke's Rifles, 100 Sirmoor Battalion, 100 4th Sikhs, total 1,150 infantry, with cavalry and six guns in support, moved down to Ludlow Castle, to capture the two field guns which had been annoying us from the front of the stable of Metcalfe's house. The operation was successful, four light guns being seized on the road by Ludlow Castle, many of the gunners being bayoneted, and considerable loss inflicted on the enemy. Our loss was 19 killed and 90 wounded. Lieut. Sheriff, 2nd Fusiliers, was wounded mortally; Brigadier Showers and Major Coke, severely; Lieut. Owen, 1st Fusiliers, and the orderly officer to Brigadier Showers, lightly.

On the night of the 19th August, reports having been received

that Lieut. Hodson—who had gone in the direction of Rohtuk, to watch a body of mutineers, supposed to have moved in that direction—was in difficulties, a force consisting of about 1,000 infantry, 200 Mooltanee Horse, some Guide Cavalry, and six guns under Major Tombs, the whole under Brig.-General Nicholson, marched at 11 p.m. to relieve him. The rain fell in torrents, and the column returned, having found the road impracticable beyond Alipoor. On the 22nd the enemy brought out three light guns, and about midday made a feeble attack on the centre battery, occupying the gardens below it, and firing up into the embrasures, but they retired again in the afternoon. On the 24th, Capt. Taylor, with Lieuts. Medley, Home and Thomason, made a reconnaissance of the ground from the Pagoda picquet to Marshall's house. The enemy's skirmishers fired heavily at the party, and one Goorkha was mortally wounded.

On the 25th August, Brig.-General Nicholson, with a force consisting of about 2,200 men of all ranks, and 12 guns, started at 4 a.m. to meet a body of the enemy, which, it was understood, had left the city on the previous day for Nujufgurh, with a view of coming upon our rear. In the evening he came upon them posted in strength near the village of Nujufgurh, and drove them from it with small loss, taking 13 guns. Several men from Coke's Corps and the 61st were wounded in an attack on another village, in which the enemy had taken refuge, and which was walled and difficult of access. Here Lieut. Lumsden, Acting Commandant of the Corps, was, unfortunately, killed, and also Lieut. Gabbett, of the 61st, and Lieut. Elkington, of the same regiment. The rebels left all their camp equipment behind them.

On the afternoon of the 26th the rebels attacked our right, bringing out six guns. Apparently, they supposed that the main body of our troops had gone out with Nicholson's column. About 50 sowars rashly charged up to within 50 yards of Salkeld's Battery, where many paid the penalty of their rashness with their lives. Our casualties were 12 in this affair. General Nicholson's column returned at dusk.

On the 27th a battery for six light guns was marked out in the Pagoda left trench. The enemy fired a good deal at our working parties, but without doing any harm, and our batteries sustained their fire.

On the 1st September, a shell fired from the other side of the river bursting in the Metcalfe stable killed and wounded nine men, these being the first casualties that had occurred from this battery.

On the night of September 3rd—4th, Lieut. Tennant (afterwards Lieut.-General, C.I.E., F.R.S.) was sent down to construct a battery for two light guns on the right of the 6-gun battery, to fire across the front of the Sammy House. A road for light guns was

made to the 6-gun battery. A magazine was commenced for the 6-gun battery, but little progress was made owing to the stony soil.

The siege guns arrived on the 5th September, the remainder of the 60th Rifles on the 6th, and the Jummoo Contingent, led by Richard Lawrence, on the 8th. All was now ready for the breaching of the city walls and the subsequent assault.

Assault of Delhi and Capture of the City.

Before describing the siege operations which commenced on the 7th September, it will be as well here to mention briefly the leading characteristics of the place, the description being taken from the Chief Engineer's Report.

The eastern face of the city rests on the Jumna, and during the season of the year when our operations were carried on the stream may be described as washing the base of the walls. All access to a besieger on the river front is therefore, impracticable. The defences here consist of an irregular wall, with occasional bastions and towers, and about one-half of the length of the river face is occupied by the King's Palace, and its outwork, the old Mogul Fort of Selimgurh.

The river may be described as the chord of a rough arc formed by the remaining defences of the place. These consist of a succession of bastioned fronts, the connecting curtains being very long, and the outworks limited to only a crown work at the Ajmeer Gate, and Martello Towers mounting a single gun at such points as require some additional flanking fire to that given by the bastions themselves.

The bastions were small, mounting generally three guns in each face, two in each flank, and one in embrasure at the salient. They were provided with masonry parapets about 12 ft. in thickness, and have a relief of about 16 ft. above the plane of site. The curtain consists of a simple masonry wall or rampart, 16 ft. in height, 11 ft. thick at top, and 14 or 15 ft. at bottom. This main wall carried a loophole for musketry 8 ft. in height and 3 ft. in thickness. The whole land front was covered by a berm varying from 16 to 30 ft. in width, and having a scarp wall 8 ft. high. Exterior to this is a dry ditch about 25 ft. in width and from 16 to 20 ft. in depth. The glacis was a very short one, extending only 50 or 60 yards from the counterscarp. The ground occupied by the besieging force presents some features deserving of notice as having exercised a most important influence on the plan and progress of the works of the attack. On the western side of Delhi there appear the last outlying spurs of the Aravelli Mountains, represented here by a low ridge, which disappears at its intersection with the Jumna about 2 miles above the place. The drainage from the eastern slope of the ridge finds its way to the river along the northern and north-western faces of the city, and has formed there a succession of parallel or connected ravines of considerable depth. By taking

advantage of these hollow ways, admirable cover was constantly obtained by the troops, and the labour of the siege was materially reduced. The whole of the exterior of the place presents a mass of old buildings of all kinds, of thick brushwood, and occasional clumps of trees, giving great facilities for cover, which during the siege operations proved, on the whole, more favourable to us than to the enemy.

In anticipation of the siege, means had been taken to store the Engineer Park with all the materials and tools required during the operations. The arrival of the siege train having placed the artillery in an equally satisfactory condition, ground was broken as soon after its arrival as possible, being on the night of the 7th September, 1857.

The project of attack submitted by the Chief Engineer to the Major-General commanding, and honoured with his sanction, provided for a concentrated rapid and vigorous attack on the front of the place included between the Water or Moree and Cashmere Bastions, provision being made at the same time for silencing all important flanking fire, whether of artillery or musketry, that could be brought to bear on the lines of advance to be taken by the assaulting columns. Due care was also taken to protect the exposed right flank of the trenches from sorties. The left was secured by being rested on the river, and by the occupation of the Koodsea Bagh, a very strong post in front.

The best information procurable indicated that on the front of attack the fire of some 25 to 30 pieces would have to be subdued. To effect this, 54 siege guns were available.

Capt. Taylor, as has been before mentioned, succeeded on several occasions in penetrating alone through the enemy's outposts, for the purpose of studying the ground, and on the general information so obtained, and his own knowledge of the locality, Major Baird Smith prepared the project of the attack. On the evening of the 6th September the project was formally considered by General Wilson. General Nicholson volunteered to accompany Taylor to see the ground and the points selected for the batteries. It was now dark, and they did not know the strength or disposition of the rebels. They went to some of the places of most importance, and found them unoccupied. Nicholson was satisfied, and reported what he had seen to General Wilson, who then gave his sanction to the Chief Engineer's proposals.

The plan of attack consisted, in principle, in establishing on the front of the fortification selected an artillery fire so much more powerful than that of the enemy on the same front that the result must be to silence his guns and crush his works. The Chief Engineer had good information that on the front between the river and the Cashmere Bastion not more than 30 heavy guns could be brought to bear upon our approaches. So arrangements were made for

placing 56 pieces of siege ordnance, of various calibres, against this front, and in about four days the whole opened with terrific effect. Two excellent breaches were made in the walls within 48 hours; the cover for the enemy's infantry was at the same time utterly swept away; an incessant storm of shot and shell poured into the place, and on the 14th September all was ready for the final assault, which was accordingly given with brilliant success.

On the 7th September General Wilson issued an address to the troops, complimenting them upon their past conduct, warning them that the hardest part of their task was now about to begin, but assuring them that if they maintained their discipline they could not fail to succeed, and bidding them spare women and children, but give no quarter to mutineers. About the same time the last reinforcements arrived from the Punjab.

The officers and men were regularly practiced in the loading and unloading of the siege materials on camels, and every vicissitude that would be likely to occur was duly provided for. It was necessary that the attack should be directed against the northern face, represented by the Moree, Cashmere, and Water Bastions, with the curtain wall between them. The evening of the 7th was fixed for the commencement of the tracing of the assailing batteries. Under the orders of Lieut. W. Greathed, No. 2 Battery was traced. This battery was situated in front of Ludlow Castle, 500 yards distant from the Cashmere Gate. It was designed with the object of silencing the fire from the Cashmere Bastion, to dismantle the parapets of the walls to the right and left which gave cover to the defenders, and to open a breach to the stormers. About 1,400 camels were employed to carry the fascines and other siege materials. The camels were quietly loaded, and the working parties marched off at dusk on the evening of the 7th.

For about a fortnight previous to the commencement of the siege batteries, large working parties were sent out to cut the trees and bushes near the sites proposed for the batteries. The men were at work from dusk to dawn, groping and stumbling about in the long, rank jungle, wet through with the rain and dew, and frequently attacked by the enemy.

On the 9th, 10th, 11th, and 12th, the batteries were completed. These were of great size, built up to the soles of the embrasures entirely of fascines. 1,500 camels were employed nightly in carrying down the fascines. The third battery was completed on the night of the 11th. This battery was traced by Capt. Medley on the evening of the 9th. With a boldness which was not rare, but the display of which in this instance testified to remarkable negligence on the part of the enemy, the engineers supported by volunteers traced this battery within 160 yards of the Water Bastion. Seeking for a fit site for the battery, Capt. Medley discovered a small ruined

building, an out-office of the Custom House, totally unoccupied by the enemy. Capt. Medley took possession of the Custom House, and determined to trace the battery inside the small ruined building, the outer wall of which would conceal the work, and give cover to the workmen. This daring measure completely succeeded.

Everyone expected that the attention of the enemy would be attracted on the first night to the grunting and noise of the camels, but, strange to say, the animals were unusually quiet. Strange, also, though it may seem, the enemy fired very little on the batteries which were under construction, although a heavy fire was concentrated upon them after they were completed and had opened fire. Almost all the engineer officers present, and fit for duty, were on duty for three nights continuously at this period.

On the 12th the batteries opened fire, and the first salvo carried away a large portion of the wall of the Cashmere Bastion. No. 1 Battery consisted of five 18-pounders, one 8-in. howitzer, four 24-pounders. No. 2 Battery was placed in front of Ludlow Castle, and consisted of two 18-pounders, nine 24-pounders, and seven 8-in. howitzers. A battery of six 9-pounders and two 24-pounders, under Major Remington, had been placed below Hindoo Rao's house, so as to play on the Moree Bastion. No. 1 Battery, which was within 700 yards of the walls, was planted in advance of this. Four guns of this battery were directed against the Cashmere Bastion, and six against the Moree Bastion. The batteries in this position were under the command of Major Brind.

There was also a battery of 10 mortars under Major Tombs, and another battery at the Custom House under Major Scott. During the construction of the former battery, a rocket fired from the Moree Bastion ricochetted among the coolies employed in the battery, killing 13. Their comrades placed the bodies in a row, and went on with their work as before.

From the 9th to the 14th, the morning of the assault, the pounding went on day and night from about 50 guns and mortars. The Moree bastion was soon silenced, and the line of parapet which sheltered the sharpshooters was stripped. The Cashmere Bastion was silenced in 10 minutes after the Ludlow batteries opened upon it.

In a letter from the Chief Engineer to Major Brind, commanding the artillery, the former wrote :—" No. 1 Battery was unquestionably the key of the attack, on its success depended the opening of Delhi to our assaulting columns. The progress of the other batteries depended essentially on its efficiency, and but for your moral courage, clear perception, and unwavering resolution in arming and working it in spite of all obstacles, consequences would have followed causing the greatest embarrassment."

The fire from the left section of No. 1 Battery had been steadily directed against the Cashmere Bastion, when about noon on the 10th

the half-battery caught fire from the constant discharge of the guns. The rebels at once directed on the burning battery every gun they could command, and it was only saved by the gallantry of Lieut. Lockhart, who was on duty at the battery with two companies of the 2nd Goorkhas. Calling for volunteers, this officer jumped on the parapet, followed by six or seven Goorkhas, and, taking the sandbags from the top, they smothered the fire with the sand. Two of the Goorkhas were shot dead, and Lockhart was shot through the jaw, but by great exertions the survivors succeeded in extinguishing the fire.

On the 11th, the mortar battery opened fire, and Scott's heavy battery was unmasked.

An hour before noon on the 12th, No. 3 Battery on the left was unmasked. It was situated in the Old Custom House, and was constructed to a great extent of sandbags. It was here that Major Fagan, of the Artillery, was killed on the afternoon of the 13th.

In the Water Bastion the fire from the heavy guns at the Custom House, at 160 yards, played with fearful effect; the guns were dismounted and smashed, and the breach opened; while under the play of Tombs's mortars the curtain was literally stripped. The losses of the British from the enfilading fire of the enemy were very heavy, but the assault was no longer to be delayed and on the night of the 13th the order was issued for it to take place at daybreak on the following morning.

The dangerous duty of examining the breaches was performed by three engineer officers, Lieuts. Medley,* Lang,† and Greathed.‡ Medley and Lang crept out and reached the edge of the ditch undiscovered, descended into it, and although they saw the enemy was on the alert they carefully examined the breach. A volley was fired at them, but they returned unhurt, and reported the breach practicable. A similar report was received of the breach in the Water Bastion.

There were to be four columns of attack, with a reserve; the first was to storm the breach in the Cashmere Bastion, the second that in the Water Bastion, the third to enter by the Cashmere Gate, when, blown in by the engineers, and the fourth on the extreme right to clear the Kissengunge Suburb, and then enter by the Lahore Gate, while the reserve was to follow in the wake of the first three columns, and throw in supports when necessary.

The columns consisted of:—

No. 1.—Under General Nicholson, 1,000 men; engineer officers, Lieuts. Medley, Lang and Bingham.

* Lieut.-General Medley entered the Service in 1847, and died in 1886.

† Colonel Lang, C.B., R.E., subsequently head of the Thomason Civil Engineering College, Roorkee.

‡ Major-General W. W. Greathed, C.B., died December, 1878.

No. 2.—Under Brig.-General Jones, 61st Regiment, 800 men; engineer officers, Lieuts. Greathed, Hovenden, and Pemberton.

No. 3.—Under Colonel Campbell, 52nd Light Infantry, 1,000 men; engineer officers, Lieuts. Home, Salkeld, and Tandy.

No. 4.—Under Major Reid, Commanding Sirmoor Battalion, 780 men; engineer officers, Lieuts. Maunsell and Tennant.

Reserve.—Under Brig.-General Longfield, 1,200 men; engineer officers, Lieuts. Ward and Thackeray.

After being told off to the different columns, the officers joined the storming parties, and marched with the column to their respective posts. The guns from the batteries, which had kept up a heavy fire during the night, suddenly ceased, and for a few minutes there was a lull in the firing, and an unusual stillness seemed to prevail. This was suddenly broken by a loud explosion from the Cashmere Gate, and by a fierce battle of musketry from the different columns of assault.

It was just daylight when the third column halted at a turn in the road which concealed them from view of the walls, but close to the Cashmere Gate. Lieuts. Home and Salkeld, of the engineers, and Sergts. Carmichael, Burgess and Smith, and four sappers, with Havildar Madho and Bugler Hawthorn, H.M. 52nd Regt., advanced from the column up to the gate. It was an immensely heavy wooden gate, flanked on all sides by the walls. Home laid the powder bags at the foot of the gate. The party was instantly discovered, and a heavy fire opened upon them from all sides. Sergt. Carmichael took the fuze, and was on the point of firing it when he was shot dead by a Sepoy who placed his musket through a hole in the gate. Sergt. Burgess took the fuze from his hand, and was also shot dead, Lieut. Salkeld then took the fuze, and was shot through the arm, and fell into the ditch, breaking his leg by the fall. As he fell he threw up the fuze, which Sergt. Smith seized, and fired the charge, and jumped into the ditch. At the same time the bugler sounded the advance, and on rushed the column. The charge blew up the gate, and about 17 of the enemy who were close to it. The following native officers, N.C.O.'s, and sappers formed part of the explosion party:—Subahdar Tooloo, Havildar Tillok (wounded), Havildar Madho (wounded), Sepoy Rambeth (killed), Sepoy Jahub Singh. Our troops rushed in at the gate, up the bastion, and along the walls. At the same time the first and second columns attacked by the breaches, and the walls were cleared of the defenders. The Cashmere Gate presented a terrible sight; several Sepoys had been blown up by the explosion, and others bayoneted or shot by the assailants, were lying all about. The same scene of carnage and destruction was visible along the walls and bastions. No quarter was asked or given. Almost every gun was dismounted and smashed by the fire from our guns, large pieces

of iron being in many cases knocked out of the guns. Dead Sepoys lay about in all imaginable positions. The troops took up positions in the College and Church, but the enemy fired constantly during the whole of the night of the 14th. Hundreds of wounded men were carried by in doolies; General Nicholson was shot near the Burn Bastion while endeavouring to rally the men. At dusk a battery was constructed near the College, and commenced shelling the town and palace. The battery was under the command of Capt. Hamilton (afterwards Lieut.-General Sir W. Hamilton), and a heavy fire was kept up on the city from this battery during the whole of the night of the 14th. The losses in the assault and taking of the city were 64 officers and 1,380 men killed and wounded.

Surgeon H. T. Reade (now Surgeon-General and C.B.) was one of the first in the breach, and succeeded in spiking a gun. Capt. R. H. Shebbeare, 60th N.I., was severely wounded while endeavouring to capture a loopholed serai. The name of Ensign Phillips, 11th Bengal N.I., was proverbial on the Delhi Field Force for the number of gallant acts performed during the siege. He was thrice wounded, and captured the Water Bastion on the 14th September with a small party of men. This gallant and promising young officer was killed during the street fighting on the 18th. These officers were awarded the V.C. for their conduct on the 14th.

Among the non-commissioned officers who greatly distinguished themselves on the day of the assault were Colour-Sergt. Waller, 60th Rifles, by charging and capturing a gun; Sergt. MacGunnis and Drummer Ryan, of the 75th Regiment, by throwing ammunition boxes into the water, thus saving many lives; Lance-Corpl. H. Smith, 52nd Regiment, by removing a wounded comrade under a heavy fire at the Chandnee Chowk; Sergt. J. Smith and Bugler Hawthorn, who were with Lieuts. Home and Salkeld at the Cashmere Gate. All these men obtained the V.C., and Sergt. J. Smith afterwards obtained a commission. Scott's Field Battery, which had entered the city by the Cashmere Gate, had during all this time rendered splendid service to the several columns, but at a large expenditure of life.

At the assault on the 14th, the storming party under Capt. Baynes, H.M. 8th Regiment, lost the greater part of their number. On the same day, from a detachment of 200 men of the 9th Lancers, the losses were 6 officers and 42 men. Of the 17 engineer officers engaged, Lieut. Tandy was killed, and Salkeld died from his wounds a few days afterwards. Lieuts. Greathed, Maunsell, Chesney,* Medley, Hovenden and Pemberton were wounded. The losses during the fighting on the 14th were 8 European officers and 162 rank and file killed, and 510 wounded. Of natives 103 were killed and 310 wounded.

* Afterwards General Sir George Chesney, K.C.B., C.S.I., C.I.E., R.E.

On the 16th the magazine was stormed by H.M. 61st Regiment, Wilde's Punjabees, and the Beloochees, the whole under Colonel Deacon, of the 61st. The enemy was surprised, and offered very little resistance, but in the afternoon made an attack in great force on the magazine. A heavy fire was opened on the turrets, where men of the 61st were posted to keep down the enemy's fire. The rebels set fire to the roof of the magazine, the fire being extinguished with much difficulty, and Renny, of the Artillery, got upon the roof with some 10-in. shells, which were handed up to him, and which he dropped on the enemy's heads. He dropped five or six shells in this manner, and many of the enemy must have been killed, as they ceased their attack soon afterwards. Capt. Renny and Lieut. Thackeray were awarded the V.C. on this occasion.

On the 18th a reconnaissance was made by Major Taylor who penetrated as far as the Chandnee Chowk; he found the houses partly occupied by their usual inhabitants, and not by an armed enemy. On the 19th, with a small detachment, Taylor worked through the houses and captured the Burn Bastion. The enemy kept up a slack fire during the night and shortly afterwards the palace was captured, and the whole city was in our possession. The defeated rebels fled in every direction, and the British flag once more waved over the walls of the capital of Northern India.

A memorial monument commemorates the capture of Delhi. The besieging army subscribed one day's pay towards its erection but this sum, though amounting to nearly 20,000 rupees, falling short of the estimate, the building was taken in hand by the Government, and completed at a cost of 21,400 rupees. It is built on the ridge, on the site of the right battery and being 110 ft. high, is visible from every point. It bears on its faces the names of the officers and men of the several British regiments, and of the British officers of the native regiments, who fell during the siege.

THE ABOR EXPEDITION SURVEY DETACHMENT, 1911–12, AND OF THE ABOR EXPLORATION SURVEY DETACHMENT, 1912–13.

(Concluded).

By CAPT. O. H. B. TRENCHARD, R.E.

Reproduced by the kind permission of COLONEL SIR S. G. BURRARD, K.C.S.I., F.R.S., R.E., *Surveyor-General of India, from the "Records of the Survey of India," Vol. IV.*, 1914.

Early in the autumn of 1912 the Government of India decided, with the sanction of the Secretary of State, to renew during the ensuing cold weather the exploration of the Dihāng River Basin in continuation of the work of the previous winter.

The programme laid down for the season was as follows:—

(1). *The Dihāng Party.*—To explore and fix the Doshung La, and discover as much as possible of the geography north of the main ranges of the Himālayas; ascertain the point where the Tsan-po breaks through the main range; fix this range west of the Dihāng in conjunction with the Siom-Sigong party; fix the main range as far as possible east of the Dihāng; discover whether the course of the Nagong * Chu is north or south of the main range and whether it flows into the Tsan-po, the Dihāng or the Dibāng.

(2). *The Siom-Sigong Party.*—To fix the main range of the Himālayas in conjunction with the Dihāng party; fix the courses of the Siom and Sigong Rivers and explore the passes said to be at the heads of these valleys; endeavour to discover the course of the Nia Chu, whether it becomes the Subansirī, the Siom, or the Sigong, whether it flows north of the main range into the Tsan-po, or whether it breaks through the main range.

Under the orders of the Surveyor-General preparations had been proceeding in Calcutta throughout September, 1912, to enable the Survey Detachment to mobilize quickly should the proposals of the Government of India be sanctioned by the Secretary of State.

* The head-waters of which were discovered in about longitude 97° 0′ E., latitude 29° 30′ N. by A.K. in 1882.

Sanction was received early in October, 1912, and communicated by the Surveyor-General on the 7th October with orders to collect the *personnel* of the detachment, who had been warned previously, and to proceed to Assam as soon as possible.

After making all final preparations and despatching the instruments, equipment, tents, etc., of the detachment (Capt. O. H. B. Trenchard, R.E., in charge; Lieut. G. F. T. Oakes, R.E.; Lieut. P. G. Huddleston, R.E.; Surveyor Hamid Gul; Surveyor Bhamba Ram; Surveyor Anwar Ali; 38 khalasis) by river steamer to Gauhāti, Capt. Trenchard left Calcutta on the 16th October, 1912, for Shillong in order to recruit Gurkhali khalasis for the detachment and ascertain what arrangements had been made by the Assam Government for the forthcoming exploration.

As soon as orders from Government were received, the Chief Secretary to the Chief Commissioner of Assam held a conference on 22nd October of all officers connected with the frontier explorations who were then in Shillong.

Details affecting the composition of the Abor Exploration Party were discussed and a rough scheme of operations formulated for the approval of the Chief Commissioner.

All the proposals made by the conference were accepted next day by the Chief Commissioner who appointed Mr. W. C. M. Dundas, C.I.E., Political Officer in charge of the Central and Eastern Sections of the North-East Frontier at Sadiyā, as Political Officer in charge of the Abor Exploration Party. Escorts consisting of the whole Lakhimpur Battalion Military Police were detailed. Orders were given to recruit 1,800 transport coolies, and the Army Department was asked to supply a mule corps, half a company of Sappers & Miners, and a cadre of British officers and non-commissioned officers of the Supply and Transport Corps for supply services.

With the assistance of Lieut. M. A. C. Kennedy, D.S.O., Adjutant, 1/8th Gurkha Rifles, all the khalasis of the detachment were carefully selected and medically examined before the end of October. Lieut. Oakes, Lieut. Huddleston and the three surveyors also joined the detachment in Shillong before the end of the month.

Owing to the prevalence of cholera in Gauhāti and on the Shillong-Gauhāti Road arrangements were made to transport the entire *personnel* of the detachment to Gauhāti by motor-car service and to embark it on the river steamer immediately on arrival in Gauhāti.

The detachment left Shillong early on the 4th November, 1912, picked up the equipment, etc., on arrival at Gauhāti and loaded it on to the steamer which sailed the same evening for Dibrugarh, where it arrived on the 7th November, 1912.

It was unfortunately only too obvious that the start of the main operations up the Dihāng would be considerably delayed, as the first necessity was to render the mule road, constructed from Pasighat

to the Yembung River during the Abor Expedition, fit for traffic. This proved an arduous and lengthy undertaking as large portions of the track had been obliterated during the preceding monsoon season. The half-company of Sappers supplied by the Army Department did not reach Kobo until the middle of December, 1912, and the whole road was not reopened for mule traffic up to the Yembung River until the end of February, 1913.

The supply cadre and the mule corps lent to the local administration by the Army Department reached Kobo about the beginning and middle of December, 1912, respectively. The transport coolies also began to arrive in Kobo about the middle of December, 1912, and were employed on the carriage of rations up the mule road as succeeding sections were opened out by the Sappers (as a preliminary measure) for coolie traffic. The section of road between Kobo and Pasighat had been rendered passable for cart traffic by the Public Works Department during the preceding summer.

The first phase of the operations in establishing an advanced base in the Dihāng Valley at the head of the reopened mule road on the Yembung River may therefore be held to have been completed about the end of February, 1913.

It had been clear from the very beginning that little new survey work could be done during this period, as there is only one line of advance into the Dihāng Basin and this had been completely surveyed the previous winter.

A considerable quantity of useful work was however accomplished, with the assistance of the Political Officer in charge, between the middle of November, 1912, and the middle of January, 1913, while the other units of the party were collecting at Kobo, though it had perforce to be confined to the area south of the outer range.

In November and December, 1912, Lieut. Huddleston and two surveyors were able to extend the survey of the southern slopes of the outer range on the right bank of the Dihāng as far west as the Simen River, besides contouring the whole area in this direction surveyed during the previous winter. This section of the detachment and its escort were provided with transport by the Political Officer from local Abor villages, as none of the regular transport coolies had reached Kobo by then. No attempt was made to survey the belt of low-lying and densely-forested country between the southern foothills of the outer range and the north bank of the Brahmaputra; partly owing to the difficulties of obtaining a sufficiency of local transport and partly owing to the probability of incapacitating the *personnel* of the section in this malarious tract before the start of the real operations in the Dihāng Valley.

In the meantime Lieut. Oakes was employed in carrying out theodolite observations to complete the triangulation of the previous season.

Having collected some Abor coolies from the villages near Pasighat he was able to proceed to Bapu Hill (one of the stations which Lieut. Field incorporated in the new series of triangulation in the spring of 1912), completed his observations and returned to Pasighat on 11th December, 1912.

The first batch of regular transport coolies had reached this place a few days previously from Kobo, but could not be employed fully on regular daily convoy work as the road above Pasighat was not yet open for traffic.

The Political Officer in charge readily agreed therefore to spare some of these coolies from the main line of advance for a short period, so Lieut. Oakes was able to cross the river from Pasighat on 14th December, 1912, with the purpose of observing from a new station on the outer range on the east side of the Dihāng and also of completing the survey of the southern slopes of the outer range between the Dihāng and Sesseri Rivers up to a marginal line previously arranged with the Dibāng Survey Detachment.

Bhamba Ram, the third and hitherto unemployed surveyor of the detachment, accompanied Lieut. Oakes. A satisfactory connection was made with the work of Capt. Gunter's surveyor along the low divide between the Dihāng and Sesseri Rivers by the 22nd December, 1912. The party then crossed the outer range (by a very difficult track) into the Yamne Valley, Capt. Oakes reaching the summit of Kine Hill (10,010 ft.), practically the highest peak in this section of the outer range, on 27th December, 1912. The next three days were spent in carrying out theodolite observations; Capt. Oakes rejoined the party at Sibbuk Village, and the party then returned down the left banks of the Yamne and the Dihāng and recrossed to Pasighat on the 4th January, 1913.

The computations of these observations were worked out by Capts. Trenchard and Oakes in Rotung by the end of January, 1913; the co-ordinates and heights were thus obtained of 24 entirely new points and of 13 other points which had only been fixed provisionally by the triangulation carried out during the expedition. Most of these points were snow peaks situated on the main range, the general outline and direction of which began therefore to be more clearly defined.

The main outlines of the plan of operations for carrying out the survey programme had been settled by the Political Officer in charge before the close of December, 1912.

It was decided that the main advance up the Dihāng Valley from the head of the mule road at the Yembung River should be along the right bank, both to avoid the dangers of an inevitable Dihāng River crossing on the line of communications attendant on the alternative route along the left bank and also to simplify the maintenance of a detached party working in the Siom Valley.

In order that the operations of this Siom party should not unduly delay the main advance up the Dihāng Valley, the Political Officer in charge decided to restrict the number of regular transport coolies employed by it to the minimum required for carriage of baggage and a small reserve of rations; thus making the party dependent on obtaining local Abor labour for the carriage of its surplus rations, to be sent out to it monthly from the main line of communications in the Dihāng Valley.

This bold policy proved on the whole eminently successful, thanks largely to the ability, tact and knowledge of the Abors and their language displayed in the conduct of the operations of this party by Capt. Hore, in political charge. Seeing that the Siom Valley had to all intents and purposes not been visited during the Abor Expedition and it became very clear as the advance of the Exploration Party progressed that the only section among the Abors really impressed by our military superiority, as a result of that expedition, was the actual Kebang Group, against which military operations had been directed, the success achieved by the Siom party may be considered remarkable.

Lieut. Huddleston and Surveyor Hamid Gul accompanied this party, which left Rotung on the 24th January, 1913, and started work in a hitherto unsurveyed area at Kombong Village in the south-eastern corner of the Siom Valley on 28th January, 1913.

By the middle of January, 1913, mule convoys were running daily up to Rotung. The final stage of this road to the Yembung River had still to be re-made and seven stages (about 100 miles) for coolie transport of the main line of communications beyond it had to be established before the surveyors could start work in the unsurveyed area of the Dihāng Valley north of latitude 28° 55′. The only immediate survey operation therefore for the remainder of the detachment was the extension of the series of triangulation up to the snow-covered (and treeless) spur which juts out west into the Dihāng Valley about latitude 28° 45′ from the Dihāng-Dibāng Watershed.

From stations on this spur theodolite observations would not only provide intersected points for the surveyors working in the untriangulated area of Pemakoi-chen but would also determine the general position and direction of the main range east of the big Namcha Barwa Peak in longitude 95°.

The easiest route to this spur lay up the Yamne Valley which rises in its southern slopes.

The Political Officer in charge agreed to the despatch of a party with this purpose and decided to accompany it himself, both to make the political acquaintance of the Padam Abors and to supervise the recruitment of the local Abor coolies required for the transport of the party.

Capts. Trenchard and Oakes accompanied the party to carry out the triangulation and Surveyors Bhamba Ram and Anwar Ali to contour the Yamne Valley.

The party crossed from Rotung to the left bank of the Dihāng and reached Porging Village near the mouth of the Yamne on the 3rd February, 1913. It marched up the right bank of the Yamne to Sibbum Village, then crossed the river and proceeded through Sibbuk Village to Damro which was reached on the 11th February, 1913.

On this date the weather, which had been extraordinarily good ever since the detachment reached Dibrugarh early in November, 1912, broke up and a period of constant rain and mist set in for the next three months.

It was realized that the somewhat hazardous mountaineering feat of reaching the top of the peaks of this spur in bad weather and the waiting thereon for a fine interval would consume too much time and entail the withdrawal of numbers of coolies from the main line of advance up the Dihāng Valley. It was therefore decided to abandon the attempt and to make other arrangements for extending the series in the main valley itself, and in the vicinity of the line of communications.

After completing the re-survey and contouring of the Yamne Valley the party crossed the divide into the Dihāng Valley on 25th February, 1913, and reached Geku Village next day. From here Capt. Oakes and Surveyor Bhamba Ram crossed to the right bank of the Dihāng and marched to Dosing Village, near the confluence of the Shimang River, with a view to proceeding up that valley and working beyond it in the Sike Valley to assist the Siom party.

Capt. Trenchard and Surveyor Anwar Ali accompanied the remainder of the party on the return journey down the left bank of the Dihāng River to the ferry below Rotung, which was reached on the 9th March, 1913, and then proceeded up the right bank of the Dihāng with the Political Officer in charge to Dosing.

On reaching that place on 14th March it was found that the arrangements for extending the main line of communications up the valley had been disorganized somewhat by rumours of coming warfare with the Abors further north.

It was therefore found necessary to curtail the scope of Capt. Oakes' work beyond the limits of the Shimang Valley. He returned to Dosing with Surveyor Bhamba Ram on the 26th March, 1913, after meeting the Siom party at Bogu Village in the Siom Valley, and having completed the re-survey and the contouring of the Shimang Valley.

Final arrangements to ensure a methodical advance up the Dihāng Valley were then made; the Assam Government having agreed to supply a reinforcement of 1,200 transport coolies for which the

Political Officer in charge had asked early in March. These extra coolies reached Kobo in April and were at once sent up to the head of the line.

By the 24th April, 1913, the line of communications had been extended to the Angong River Confluence where the main party was rejoined by the Siom party, on completion of its work in the Siom Valley. Henceforth it ceased to exist as a separate party, exactly three months after it was constituted as such in Rotung.

As mentioned above the Siom party reached Kombong on the 24th January, 1913. Surveyor Hamid Gul first accompanied Capt. Hore into the south-west corner of the Siom Valley and completed the survey of that portion of the lower Siom Valley up to the Subansirī Watershed before he rejoined the rest of the party at Along Village on the Siom River on the 11th February, 1913.

In the meantime Lieut. Huddleston crossed to the left bank of the Siom River from Along and completed the survey of the valley of the Sirit, a small tributary of the Siom, before rejoining the party at Along.

The small area between the Sirit Confluence and the mouth of the Siom was surveyed towards the latter part of April, 1913, by Surveyor Anwar Ali.

The whole party proceeded up the right bank of the Siom River from Along and reached the confluence of the Sike River, the big northern tributary of the Siom, on the 14th March, 1913.

Despite the almost continuous rain experienced during this period the valley was surveyed right up to the Subansirī Watershed, and Surveyor Hamid Gul also managed to sketch in the head-waters of the Siu River, a big tributary of the Subansirī not completely surveyed by the Mīri Mission during the previous season.

On the 17th March, 1913, the whole party crossed the Siom River to Bogu Village on the left bank, and picked up its third and last month's supply of rations which had been sent out by convoy up the Shimang Valley from Dosing, on the main line of communications in the Dihāng Valley. It then crossed the Sike and reached Yiyu Village on the left bank of the Siom on the 25th March, 1913. A depôt of rations to feed the party on its return journey (by way of the Sike Valley) to the main line of communications in the Dihāng Valley was formed at Yiyu, and the rest of the party continued along the left bank of the Siom to complete the survey of the top portion of that valley. Ro Village was reached on the 27th March, 1913. Between Ro and the next village Pa-um the Siom breaks through a snowy range of mountains in a very narrow gorge. This range, known north of the Siom as the Pari and south of it as the Yorjing Mountains, is a very large spur of the main Himālayan Range and approximately follows the 94° 30′ meridian from north to south.

The Pari Mountains form the watershed between the Sike Valley and the top portion of the Siom Valley, while the Yorjing Mountains divide the valleys of the Siom and the Subansirī.

The trade path to the upper portion of the Siom Valley is very difficult throughout the whole length of the gorge, crossing several sheer rock faces (on which the path degenerates into a series of precarious footholes) at an altitude of about 3,000 ft. above the river bed.

The first of these cliffs, Pu-U, was encountered between Ro and Pa-um Villages. It proved so serious an obstacle that it was impossible to get any of the loads or most of the coolies across it, and the party possessed no means of improving the track by the only possible method of blasting it out of the rock face.

Moreover the attitude of the Boris, which had been distinctly unfriendly since the party entered their territory a short distance below the Sike Confluence, became openly hostile at this juncture and Ro Village had to be punished on the 29th March, 1913. Capt. Hore then decided in consultation with Lieut. Huddleston that, in view of the necessity of getting the whole party back to the main line of communications in the Dihāng Valley before its rations were exhausted, no further attempt should be made to proceed further up the Siom Valley but that the party should spend the remaining time at its disposal before returning to the Dihāng Valley in completing the survey of the Sike Valley and any other northern tributaries of the Siom.

In pursuance of this decision—the only possible one under all the circumstances with regard to the main objective of the Exploration Party in the Dihāng Valley, even though it entailed the non-fulfilment of one of the items of the survey programme laid down by the Government of India—the party returned to Yiyu, picked up the depôt there and marched up the right bank of the Sike River to Gasheng Village which was reached on the 11th April, 1913. From here Lieut. Huddleston and Surveyor Hamid Gul managed to reach the top of a peak on the watershed between the Sike and Sirapateng (Sigong) Valleys from which the survey of the head-waters of the former valley was completed and a useful start in the survey of the latter valley was made.

They rejoined the rest of the party, which had meanwhile been progressing slowly up the Sike Valley from Gasheng Village, on the 17th April and then crossed that river into the valley of the Sirang, a small tributary stream, up which the party proceeded to a pass over the top of Luyor Hill—a peculiarity common to many Abor paths—situated at the head of the Sirang and on the watershed between the Sike and Dihāng Rivers.

After halting on this hilltop for four days, the fourth day fortunately being fine and clear, the party marched down the Nidgong

River, a Dihāng tributary which like the adjoining and parallel stream the Angong flows from south to north, to Mosing Village which is built on top of a commanding bluff between the two tributaries and immediately above a deep and narrow gorge through which the Dihāng flows below this village.

From Mosing the party marched down to the Angong River Confluence on the 24th April, and rejoined the main party.

With the exception of Surveyor Anwar Ali, whom it was found impossible to employ after the end of April, 1913, owing to lack of transport and who therefore remained in reserve at the advanced base on the Yembung River for the remainder of the season, the whole detachment were collected at or near the head of the line of communications at the Angong River Confluence by the beginning of May, 1913. Capt. Oakes, who had been incapacitated for the whole of April by an attack of mumps, reached the Angong River from Dosing on the 3rd May ; and Surveyor Bhamba Ram completed the contouring of the whole area in the Dihāng Valley surveyed during the previous season up to latitude 28° 55′ by the 9th May, 1913.

Owing to the failure experienced in February, 1913, to extend the series of triangulation to the range at the top of the Yamne Valley, the northern portion of the Dihāng Valley, known as Pemakoi-chen, which the Exploration Party was now about to enter, had to remain untriangulated up to this.

Lieut. Huddleston had, however, fortunately discovered on crossing the watershed between the Sike and the Dihāng that Luyor Hill on that divide would make a suitable station and that another high hill (Dino) in the vicinity of Pango Village on the line of advance could probably be utilized as a second station from which the necessary points in Pemakoi-chen might be fixed.

A third hill (Loyung) in the vicinity of Bomo Village further down the Dihāng Valley and, like the other two, close to the line of communications, was selected as an intermediate station to connect the two forward stations with the series.

The Political Officer in charge having made all arrangements for escorts, supplies and transport immediately the suggestions for this triangulation had been put before him, the three survey officers were able to leave the Angong River to execute it before the middle of May, 1913.

Capt. Oakes reached the top of Luyor Hill on the 9th May, 1913, but owing to bad weather was not able to complete his observations until the 20th May, 1913.

Lieut. Huddleston reached the top of Loyung Hill on the 10th May, 1913, and had a very heavy job cutting down the trees on it. He managed however to complete all his observations by the 20th May, 1913.

Capt. Trenchard accompanied by Surveyor Hamid Gul left the Angong River on 10th May, 1913, to clear the top of Dino Hill and erect a signal for the other two triangulators to observe to. This was completed on the 15th May, 1913.

Capt. Oakes after completing his observations from Luyor Hill proceeded at once to Dino Hill which he reached on the 22nd May, 1913. Another spell of bad weather delayed the completion of his observations there until the 3rd June, 1913.

By this time the head of the line of communications had been advanced across the Sirapateng River and had reached Tuting, the most northerly Abor Village on the right bank of the Dihāng. Computations of all the recent triangulation were completed by the 13th June, 1913, as a result of which 40 new points were provided for the plane-tablers. Although Capt. Oakes was able to observe from one more hill (Nishing) north of Tuting Village before the end of June and obtain six more new points it was not found possible to extend the series north of latitude 29° 0′ before the close of the season.

Compared with the lower portion of the Dihāng Basin Pemakoichen proved an easy country to survey. It is not only more populous and therefore less densely forested than the Abor country ; the bold lofty spurs which run down from the main range to the river enable the plane-tabler to climb above the tree level and therefore to work far more rapidly than he can in the Abor Hills of lesser altitude.

During the first week of June, 1913, Surveyor Hamid Gul spent some days in bivouac at altitudes between 11,000 and 14,000 ft. on the Dipung Ridge, which divides the two right bank tributaries Ringang and Nugong ; from which he was able to complete the survey of the Yang Sang Chu Valley on the opposite side of the Dihāng.

Working at the same altitudes Surveyor Bhamba Ram practically completed the survey of Ringang Valley between the 3rd and 13th June, 1913. He was not able to reach the pass (Lushe La) at the head of this valley by which the Abors state a track crosses the main range into the Tsan-po Valley, as this path ceased to be practicable for loaded coolies half-way up the Ringang Valley.

The head of the line of communications was established at Kopu, the most southerly Pemakoiba village on the right bank of the Dihāng, on the 14th June, 1913. The hot weather had set in by this time, the original transport coolies had been working continuously for six months, and it was obvious that operations in the Dihāng Basin could not be continued for much longer.

The Political Officer in charge decided therefore not to extend the line of communications beyond Kopu, but to continue the advance up the Dihāng with a small self-contained party (carrying rations for 20 days) before returning to Kopu. It was also arranged that

another small party should make a similar journey up the Sirapateng (Sigong) Valley to complete the unsurveyed portion at its head and reconnoitre the pass over the main range by which a track was said to lead into the Tsan-po Valley.

The Dihāng party left Kopu on the 23rd June, Capt. Trenchard accompanying it, and picked up Capt. Oakes and Surveyor Hamid Gul, who had spent the previous week observing from the Nishing ridge and completing the survey of the Nugong Valley, on the evening of the same day.

The party reached Janyor Village on 26th June, where Surveyor Hamid Gul was detached to ascend the Jijung Ridge between the Nugong and Pemasiri Valleys. The remainder of the party reached the Pemasiri River (near Yortang Village) on the following day.

On the 28th June, 1913, Capt. Trenchard left the main party and with a small escort commanded by Capt. Pemberton, R.E., marched up the left bank of the Pemasiri River, reaching Ani Basam, one of the halting places on this important trade route just beyond the junction of the Pemasiri and the Doshung Chu that evening. On the following day he crossed the divide into the Doshung Valley and marched up the left bank of that river to the pass (the Doshung La, about 13,500 ft.) over the main range at the head of the valley. The pass, an easy one, was crossed on the 2nd July, 1913. Next day the party reached Phea Doshung, a small village on the right bank of the Tsan-po about half-way between the villages of Chilagong and Gyala, and was received in a friendly and hospitable manner by the villagers. Chilagong is an important, if not the principal, village of the Kongbu District of Tibet and is three days' ride west of Phea Doshung. Gyala is two days' ride north-east of Phea Doshung.

The 4th July was spent on a neighbouring hill, but unfortunately bad weather prevented any trigonometrical observations being carried out. A plane-table sketch however was made of the portion of the Tsan-po Valley visible from this hill and of the neighbouring areas compiled on the spot from the topographical information freely given by the local inhabitants. Lack of time and rations and the necessity of rejoining the main party in the Dihāng Valley on the arranged date rendered it impossible to continue the march from Phea Doshung to Gyala.

The headman of Gyala reached Phea Doshung however on the evening of the 4th July to visit the party and absolutely confirmed Kinthup's account of the Tsan-po breaking through the Himālayas just below his village and flowing into Pemakoi-chen on the other side of the mountains in a very deep and impassable gorge. About the falls this headman was reticent and contradictory; the general impression he gave both officers of the party was that falls undoubtedly do exist even if they are not as big as described by Kinthup.

With the knowledge that Capts. Bailey and Morshead were on their way to settle this question definitely as a partial consolation for the disappointment of not being able to forestall them, the party left Phea Doshung on the 5th July, 1913, recrossed the Doshung La the following day, and rejoined the main party on the Pemasiri River on the 9th July, 1913.

Owing to continuous bad weather both on the outward and return journey it was not found possible to survey the Doshung Valley in detail nor even to make any astronomical observations. A prismatic compass traverse of the whole route was executed, which will be adjusted eventually with Capt. Morshead's survey in the Tsan-po Valley.

The reconnaissance survey, based on this traverse, of the whole area covered during this exploration is however fairly complete.

On the 29th June, 1913, the Political Officer in charge, Capt. Oakes and the main party continued the advance from the Pemasiri River up the right bank of the Dihāng River. On the 4th July they reached the Chhanjuk La, a pass of low elevation on the south-eastern extremity of the watershed between the valleys of the Pemasiri and the Nyalam Chu.

Capt. Oakes completed the survey of the Dihāng Valley in detail up to this watershed on the right bank; on the left bank he completed the survey up to the confluence, near Khapu Village in about latitude 29° 30′, of the big left bank tributary, the Chimdru Chu, thus effecting a very satisfactory connection with the survey Capt. Morshead will have made in that valley and also in the Dihāng Valley north of latitude 29° 30′.

The party found on reaching the vicinity of Khapu that Capt. Morshead had left that village a short time previously and was proceeding up the left bank of the Dihāng towards Pomed. He had been informed previously of the extreme northern limits to which the surveys of the Abor Exploration party could be carried.

Owing to the time limit imposed by the arrangements for the retirement of the whole exploration party made before the Dihāng party left Kopu, the Political Officer in charge and Capt. Oakes were unable to continue their journey across the valley of the Nyalam Chu, the last of the big mountain torrents on the right bank of the Dihāng, and reach the eastern end of the big gorge through the Himālayas.

The return journey down the Dihāng Valley was started on the 5th July, 1913, the Pemasiri River being reached on the 9th July, 1913.

Surveyor Hamid Gul, having reached the top of the Jijung Ridge from Janyor Village on the 28th June, 1913, spent a week in completing the survey of the southern and western portions of the Doshung Valley up to the crest of the main range. Continuous bad

weather prevented him from completing the detailed survey of the whole of the Doshung and Pemasiri Valleys; he was however able to do a certain amount of reconnaissance work which, combined with that of Capts. Trenchard and Oakes in this area, provides a complete and fairly accurate survey of the main range at the head of the Doshung and Pemasiri Valleys up to the big Namcha Barwa Peak, and also of the two valleys up to the Pemasiri-Nyalam Chu Watershed which takes off from the main range in the vicinity of that peak. Surveyor Hamid Gul rejoined the main party at the Pemasiri River on the 9th July, 1913.

Next day the reunited party started its long march down the Dihāng Valley, acting as the rear guard of the whole exploration party during the retirement to Kobo, which was reached on the 9th August, 1913.

While the main Dihāng party was making its final advance up that valley Lieut. Huddleston and Surveyor Bhamba Ram accompanied a small party under the command of Capt. Hore up the Sirapateng Valley. Leaving Miging Village on the main line of communications in the Dihāng Valley on the 19th June, 1913, the party crossed to the left bank of the Sirapateng (Sigong) River at Kerak on the 21st June and continued its advance up the valley. The junction of the Simu with the Sirapateng River was reached on the 27th June and from here the party proceeded up the left bank of the Simu River to the top of the valley, reaching the Lungma (Lulung) La, the 13,500 pass on the main range by which the track crosses into the Tsan-po Valley, on the 30th June.

Orang Gacha, a village on the right bank of the Tsan-po, is said to be only two days' march by a good *Yak* road from the Lungma La. The party had been delayed considerably in its advance up the Sirapateng Valley by the extremely bad condition of the alleged trade route. Much time was spent in repairing and rebuilding the cane bridges over the numerous side streams, all of which were in flood from the continuous rain experienced throughout the whole journey.

The party was unable therefore to continue its advance over the Lungma La into the Tsan-po Valley in the time allotted for this exploration, nor could Lieut. Huddleston carry out any survey of the western slopes of the main range from the pass. The continuous bad weather made it impossible even to survey the Sirapateng Valley in detail; a prismatic compass traverse of the route was made and the reconnaissance survey of the whole valley based on this traverse is complete and very fairly accurate.

The party returned to Miging Village on the 7th July, 1913, where Lieut. Huddleston was employed for the next week in determining an accurate height by theodolite observations for the Sirapateng Confluence. Thence he and Surveyor Bhamba Ram marched down

the Dihāng Valley, reaching Pasighat on the 26th July and Kobo on the 9th August, 1913.

The whole detachment embarked on a river steamer at Kobo on the 14th August and reached Gauhāti on the 17th August, where the khalasis were paid off and discharged.

The officers and surveyors of the detachment, who had been transferred to the headquarters of the Eastern Circle on demobilization of the Abor Exploration party, reached Shillong on the 18th August, 1913.

Despite the length of the season, which lasted from the 7th November, 1912, until the 14th August, 1913, the detachment did not experience much sickness. One officer had an attack of mumps in April, 1913, and the other two officers suffered from malaria during the return journey to Kobo in July and August, 1913. The surveyors and khalasis escaped serious sickness in a remarkable manner; only one khalasi had a mild attack of pneumonia during March, 1913.

A short recapitulation of the Survey work accomplished in the basin of the Dihāng River partly during 1911–12 but mostly in the season 1912–13 will show to what extent the requirements of the Government of India have been fulfilled.

With exception of the head-waters of the Siom River the whole area of the Dihāng River Basin, from the Brahmaputra River in the south to the confines of Tibet and Pomed in the north, has been surveyed in detail—for the most part rigorously—on the scale of 4 miles to 1 inch, the hill features being delineated by approximate contours at 250-ft. vertical interval.

Satisfactory connections along the entire lengths of the common margins have been made with the surveys of the Dibāng Exploration party to the east along the Dihāng-Dibāng Watershed, and with the surveys of the Mīri Mission of 1911–12 to the west along the Dihāng-Subansirī Watershed.

The southern slopes of the outer range of the north bank of the Brahmaputra River from the Simen River in the west to the Sesseri River in the east, an area which, strictly speaking, is not contained in the actual basin of the Dihāng River, have also been surveyed in detail.

The detail surveys are based on a good minor series of triangulation which emanating from the Assam Valley (G.T.) series in the Brahmaputra Valley, has been carried over the outer range and extended into the Dihāng Valley up to latitude 28° 55′. From this series of triangulation 30 peaks have been intersected on the main range of the Assam Himālayas bounding the basin to the north and north-west which determine the position and direction of the range from longitude 94° in the south-west to longitude 95° in the north-east.

The greater portion of the entire length of this section of the main range has also been surveyed in detail (on the Dihāng side)

up to the crest of the range; only the small portion at the head of the Siom Valley between longitude 94° and 94° 15′ has not been surveyed in addition to being fixed by triangulation.

Two passes on the main range by which the two main trade routes from the Dihāng Valley cross into the Tsan-po Valley—the Doshung La at the head of the river of that name, and the Lungma (Lulung) La at the head of the Simu branch of the Sirapateng (Sigong) River—have been accurately fixed and the routes leading to them surveyed. In addition four passes of minor importance, the Deyan La and Demya La at the top of the Nugong Valley, the Lushe La at the top of the Ringang Valley, and an unnamed pass at the head of the Sirapateng River, have been fixed approximately; the paths leading to them were not completely surveyed only because they were found impossible for loaded coolies.

Finally the approximate positions of the Nam La, by which the route from the northern part of Pemakoi-chen up the Nyalam Chu crosses the main range to Gyala, and that of the Tunga La at the head of the Siom Valley have been obtained from local information.

The course of the Dihāng River itself and those of all its tributaries south of latitude 29° 30′ (except the head-waters of the Siom) have been accurately surveyed up to that parallel.

The correct position of the Tsan-po River in the neighbourhood of Gyala has also been determined, which enables us to correct the course of that river as shown on existing maps from Chetang to Gyala; and a certain amount of new geographical knowledge about the country to the north of the main range has been obtained.

The identity of the Tsan-po and the Dihāng as one and the same river has been established to all intents and purposes. Kinthup's statement that the Tsan-po broke through the Himālayas from Tibet to Pemakoi-chen in a deep gorge has been confirmed, the position of this gorge has been fixed with a fair degree of exactitude, and only a short length of the Dihāng River (probably not more than 30 miles measured along the bends of the river) between latitude 29° 30′ and the eastern end of the gorge in about latitude 29° 45′ has not been surveyed, though actually we are able to show this small portion on the map with tolerable certitude from local information pending the final confirmation of Capt. Morshead's surveys.

These will also confirm and of course correct the sketch map, which has been compiled from local information, of the areas known as Potodh, Pomed and Poyul which lie to the north of Pemakoi-chen and which are drained by the big river Po Tsang Chu and its tributaries.

The head-waters of this river (known as Nagong Chu) were discovered by Surveyor A.K. in the autumn of 1882 flowing west after rising in the mountains in which Shuiden Gom-pa is situated in about latitude 29° 30′, longitude 97° 0′.

It is now clearly established (though actual surveys in confirmation are still wanting) that this Nagong Chu or Po Tsang Chu does not flow into the Dibāng River or into the Rong Thod Chu, but that it joins the Dihāng River in the vicinity of Gompone Monastery at or near the eastern end of the big gorge through the Himālayas. Whether this river pierces the main range at any point higher up in its course must remain a moot point until the question is settled on Capt. Morshead's return to India; all the evidence we have obtained up to the present points to the fact that the big range of mountains discovered by A.K. in 1882 on his return journey to Lhāsa from Shuiden Gom-pa, which bounds Potodh, Pomed, and Poyul on the north, and divides that country from the valley of the Giama-Nu Chu (or Upper Salween River) is probably a section of the main range of Himālayas; in which case the Po Tsang Chu would not break through it at any point.

Unfortunately it was impossible to carry out that particular requirement of the Government of India to fix the main range east (or probably north) of the Tsan-po Gorge.

If, as has been suggested above, the range trends nearly due north from the gorge—and visual evidence was obtained at Phea Doshung to support this theory—and joins the mountains which divide Potodh, Pomed, and Poyul on the south from the valley of the Giama-Nu Chu on the north, it would not be possible to survey or even fix the direction of such a range approximately without entering Pomed.

This the Abor Exploration party was unable to do, even had time permitted, owing to an insufficiency of transport and escort.

As a net result of the surveys executed during 1912–13 it may fairly be claimed that the whole programme of survey for the Abor Exploration party as laid down by the Government of India has been practically accomplished.

During the Abor Expedition in 1911–12 a short series of triangulation, based on the side Nāri H.S. and Dutia P.S. of the Assam Valley (G.T.) series (Synoptical Vol. XXII.), was carried northwards over the outer range into the Dihāng Valley. Two stations of this series, Bapu h. s. and Torne h. s., are situated on the outer range; the other two terminal stations, Sadap h. s. and Namkam h. s., are situated in the lower portion of the Dihāng Valley in about the latitude of Kebang Village. Namkam h. s. is on the left bank of the Dihāng, on the southern end of the watershed between that river and the Yamne; the other three stations are on the right bank of the Dihāng River. When this series was computed during the summer of 1912 the figures were "ground down" roughly; the mean triangular error is 4·0 seconds and the mean linear error for four common sides is 1·8 in. per mile.

It may therefore be classed as good "minor" triangulation or

even better. A fifth station Pangi h. s. was observed at in connection with the series, but the triangle Torne-Sadap-Pangi is a supplementary one and not part of the series.

North of the series five independent stations in the Dihāng Valley were observed from—Arte, Simong, Geku, Shumsing and Peram. They could not be connected with the series in the ordinary way and were computed by interpolation from some of the intersected points fixed from stations of the series.

Altogether 45 new intersected points were fixed during 1911–12.

In 1912–13 the series was considerably extended by the Abor Exploration party. Bapu h. s. was re-observed at and a new station, Kine h. s., situated on the outer range east of the Dihāng, was also established before the close of 1912. Kine was fixed by two triangles, one angle of each being unobserved. The observations were however made to opaque signals and the two values obtained for the side Kine-Bapu show a discrepancy of only 1·3 ft., or 0·9 in. per mile, so that Kine may be considered well fixed.

A plain's station was also fixed in December, 1912, at Pasighat, included in the series chiefly to provide an accurate point for the closing of traverses across the plains between the Brahmaputra and the outer range in future.

After the failure of an attempt, made in February, 1913, to extend the series northwards by establishing stations on the big spur at the head of the Yamne Valley, the series was eventually completed about the beginning of June, 1913, by observations made from three new stations west of the Dihāng River, Loyung h. s., Luyor h. s., and Dino h. s.

The first is situated on the right bank of the Dihāng near Bomo Village, the second on the Sike-Dihāng watershed, and the third on the right bank of the Dihāng near Pango Village.

Though all the angles of this triangle Loyung-Luyor-Dino were observed to signals, the triangular error being 3 seconds only, it was not possible to connect it with the two forward stations in the series of the previous season. The connection with the series had to be made as follows:—The side Kine-Loyung was obtained from triangles (with one angle of each unobserved) off five well-fixed intersected points. A mean of the values was taken giving a probable error of 12 ft., or 0·3 in. per mile. Off the *corrected* sides of the same five triangles the side Loyung-Dino was obtained, the mean of the five values giving a probable error of 5 ft., or 3·4 in. per mile. From this mean value of the side Loyung-Dino, the triangle Dino-Loyung-Luyor was computed, giving one value for the side Loyung-Luyor. Another value for this side was obtained, the mean giving a probable error of 10 ft. or 9·7 in. per mile.

These two values for the side Loyung-Luyor differed by 4 ft. only, or 3·8 in. per mile. The mean of these two values was accepted

as the final base from which the triangle Loyung-Luyor-Dino was recomputed.

North of these three stations, but unconnected with them, an interpolation was made from several well-fixed intersected points at Nishing h. s., on the ridge of the same name near Geling Village, towards the end of June, 1913, to provide a few more intersected points for the plane-tablers. In addition one station with an auxiliary station near it was made at Miging Village in July, 1913, for the purpose of obtaining an accurate value of the height of the Dihāng River at its junction with the Sirapateng River (1,270 ft.).

As a result of the triangulation carried out in 1912–13 it has been decided to treat the five independent stations, Arte, Simong, Geku, Shumsing and Peram of 1911–12 merely as intersected points, and all work dependent on them has therefore been rejected. Many of the intersected points fixed in 1911–12, having been fixed more accurately in 1912–13, have also been recomputed.

The total number of intersected points which have been finally obtained from the triangulation of both seasons is 125.

No useful purpose would be served in working out a mean linear error for all these intersected points, as so many special factors which cause the errors to vary abnormally in any trans-frontier triangulation would have to be taken into consideration.

Errors in rays to sharply-defined snow peaks for instance are naturally less in proportion than in rays to rounded jungle-clad hills. The quality also of the northern portion of the series as triangulation is not, by nature of its connection, as good as the southern portion.

The most accurately fixed intersected points, viz., nine sharply-defined snow peaks, were computed in more detail than the rest because they were required for use in extending the triangulation.

These nine peaks should serve as well-fixed points from which an extension of the triangulation to the north and north-east could in future be made if necessary.

No connection has been made with the triangulation executed by the Mīri Mission Survey Detachment in 1911–12, or by the Dibāng Exploration party in 1912–13. Some of the peaks on a part of the Dihāng-Subansirī Watershed (the common margin) intersected from the Dihāng series appear to be identical with those fixed by the Mīri Mission triangulation, but there is sufficient discrepancy between the co-ordinates in nearly every case to affect the work of the plane-tabler considerably (even on the $\frac{1}{4}$-in. scale) if both sets of points are used indiscriminately.

A partial explanation of this discrepancy lies in the fact that, although both the Subansirī and Dihāng triangulation emanate from the same Assam Valley series, these identical peaks were observed from opposite sides of the watershed, different features on the same

peak being observed to from either side. Another reason is the inferiority of the Subansirī series as compared with that in the Dihāng. The Subansirī series of 1911–12 was extended from Colonel Woodthorpe's stations of 1877–78, which are connected somewhat precariously with the Assam Valley series.

If therefore the Subansirī series is ever extended northwards without revision it is doubtful whether the intersected points of the Dihāng series on this watershed can be utilized for accurate theodolite interpolations in the Subansirī Valley unless some means can be devised to connect the two series and adjust the present discrepancies.

No identical points on the common margin the Dihāng-Dibāng watershed have been fixed by the Dihāng and Dibāng triangulation. Even had the same peak been fixed in any case from either side the discrepancy between the co-ordinates would be considerable, as the two series are not in the same terms and the basis of the Dibāng triangulation is unreliable.

During both seasons it proved a difficult and troublesome matter to arrive at a satisfactory coefficient of refraction. Seeing that even in the finest spells of weather in the Dihāng Basin all snow peaks and most of the lower hilltops are invariably hidden in cloud after 8 or 9 a.m., for the rest of the day, most vertical angle observations have to be taken in the early morning instead of at the time of minimum refraction. This may possibly account for the large discrepancies which have been experienced in working out this coefficient.

Eleven reciprocal values for heights were obtained in 1911–12; five of these were from the hills to the plains, but the mean coefficient for the remaining six values in the hills worked out to ·041.

Though this figure seemed too low it was adopted in the absence of any other more reliable data to work out the heights of all the intersected points fixed in 1911–12. However, as the triangulation of 1912–13 was extended northwards, disagreements in values for heights of the more distant intersected points indicated that this coefficient was too low and that the correct coefficient would probably be about ·060 or ·065.

As a result of all the triangulation of 1912–13 seven more reciprocal height values were obtained, six of which were in the hills. The mean coefficient for these six values worked out to ·079; and the mean of the twelve values of both seasons therefore gives a coefficient of ·060.

As however the Dibāng triangulation of 1912–13 had resulted in a mean coefficient of ·069 from 21 reciprocal height values, the matter was referred to the Superintendent of the Trigonometrical Survey who decided that the usual coefficient ·070 should be adopted. The heights of all the intersected points fixed in both seasons have been recomputed with this coefficient.

5″ micrometer theodolites (by Troughton & Sims) were used both seasons. Though three khalasis are required to carry one of these instruments and its stand, this disadvantage is greatly outweighed by its superiority over a lighter vernier instrument, both in accuracy and the ease and quickness with which observations can be made.

Usually it was found quite sufficient to read only one horizontal and one vertical microscope, a great consideration on the North-East Frontier where speed in observing is all-essential owing to the limitations imposed by an extremely adverse climate.

The adjustment of the micrometers of these instruments is not affected by rough usage nearly as much as might be expected. It was only possible to use heliotropes at the one plain's station Dutia in 1911–12. Otherwise opaque signals of various types were used for all the remaining stations in both seasons; the best and most usual type of signal being a single tree left standing on all the jungle-covered hilltops, the other trees all round it being cut down.

Attempts were made on several occasions to build machans in big trees in order to save the heavy labour of clearing, but none of these attempts proved satisfactory. At two or three stations the top of a tree was cut off several feet above ground level, the stump being used as a stand for the theodolite with a rough machan built round it as a platform for the observers. This is the most satisfactory kind of machan, but skilled labour is required to remove the tree top at a sufficient height from the ground and to build a reasonably secure platform of that height.

The station marks have been cut on rocks *in situ* wherever possible; at some of the stations however the mark had to be cut on tree stumps and cannot therefore be relied on as permanent.

Mention has already been made of the extraordinarily dense vegetation which covers all the hills in the Dihāng River Basin right up to permanent snow level, and of the execrable climate, both of which offer the greatest impediments to triangulation and render hasty reconnaissance work impossible.

The heavy clearing which had to be undertaken in the preparation of every hill station, especially as the tops of the lower hills are usually flat rather than pointed, rendered it essential to select as few stations as possible, and a very large number of observations therefore had to be made at each station. The only weather suitable for triangulation is experienced between the middle of October and the middle of January. At any other time of year the triangulator must be prepared to wait several days on each hill station before one of the infrequent spells of fine weather occurs to make any work possible.

As also snow peaks and all the higher hills are only visible between dawn and 8 or 9 a.m. at all seasons of the year the triangulator must

be encamped in the immediate vicinity of the station so that he can start work at dawn. Water is seldom found near the tops of hills below snow level so arrangements must be made for carrying it up to the camp on the hilltop. Canvas chagals are useful but wear out very quickly. Choongas made out of bamboos are excellent but not always obtainable. The best arrangement of all for Survey Detachments working on the North-East Frontier would be a light metal pakhal covered with rope netting to protect it from damage, of similar pattern to the regulation mule pakhal but designed to weigh not more than 60 lbs. when full, so that it could be carried by a coolie.

During the Abor Expedition of 1911–12 the total area plane-tabled on the scale of 4 miles to 1 inch amounted to about 2,300 square miles; of this total area however only about 1,730 square miles were more or less rigorously surveyed, the remaining 570 square miles consisting of approximate reconnaissance surveys by members of the detachment. Compilations of the sketches, reports, etc., submitted by the Intelligence and other officers of the Force have not been included in the above totals.

Owing principally to the impossibility of executing any triangulation until towards the close of the expedition, plane-tabling was carried out under great difficulties in an area devoid for the most part of triangulated points.

For this reason no contouring could be done, all hill features were shown by (horizontal) hill shading.

The following table shows the total out-turns of the individual members of the Abor Expedition Survey Detachment in 1911–12:—

Name.	Out-turn, sq. miles.	Approximate Number of Working Days.
Mr. Sher Jang, Khan Bahadur	1,431	50
Surveyor Hamid Gul	1,512	60
,, Abdul Majid	230	15
,, Abdur Rahim	345	25
,, Shah Muhammad	92	4

The large difference between the aggregate of these individual out-turns and the total area (2,300 square miles) surveyed is due to the unavoidable duplication of work caused, as on most military expeditions, by the inevitable subordination of survey considerations to military and political requirements.

The numbers of working days shown in the above table are only approximate; it is impossible to work out accurate totals expressed in complete working days put in by surveyors employed with military

expeditions and exploration parties. As has been mentioned in a preceding paragraph practically the whole of the plane-tabling was accomplished in the last three months—January to March, 1912—before the Expedition returned to India.

Before the Abor Exploration party started work in 1912–13, the outline fair sheet of the previous season's work had been drawn and all the triangulation data had been computed. As the same area had to be covered again during the advance up the Dihāng Valley it was decided to contour the work of the previous season.

Blue prints on mounted drawing paper of the fair outline sheet were accordingly obtained and given to the surveyors of the Abor Exploration Survey Detachment to facilitate this work. These blue prints were attached to the plane-tables by a few strips of adhesive plaster, a small overlap of the print being first turned down all round the edge of the plane-table. This arrangement proved very satisfactory and resulted in very little distortion.

Except for the fringe of flat densely-forested country between the Brahmaputra and the outer range the whole area (about 2,000 square miles) surveyed in the previous season was thus contoured during 1912–13.

This entailed practically the re-survey of the whole of this area and incidentally disclosed the excellence of the work of Mr. Sher Jang and Surveyor Hamid Gul in 1911–12.

This work of contouring the lower portion of the Dihāng Basin was completed in the first half of the season 1912–13, while the extension northwards of the main line of communications was in progress. As the extension of the series of triangulation was also completed before the Exploration Party reached the unsurveyed area in the northern part of the Dihāng Basin, the plane-tablers were supplied with triangulated points before starting work in this area, and so were able to continue the work of contouring throughout the season.

The upper portions of two valleys only, the Sirapateng and the Doshung-Pemasiri, could not be accurately surveyed and contoured owing to the bad weather experienced while the surveyors were working in them. Reconnaissance surveys (based on prismatic compass traverses) could only be accomplished in these two cases, comprising a total area of 722 square miles. The area surveyed in detail and contoured in the remainder of the Dihāng Valley Basin during 1912–13, including the 2,000 square miles re-survey of the previous season's work, amounted to 5,478 square miles.

The total area surveyed in the Dihāng Basin during 1912–13 is therefore 6,200 square miles.

In addition a reconnaissance survey of about 140 square miles was executed by Surveyor Hamid Gul of the head-waters of the Siu Valley, a tributary of the Subansirī River.

Thus the total out-turn of the plane-tabling in 1912–13 amounts to 6,340 square miles.

The following table shows the total out-turns of the individual members of the Abor Exploration Survey Detachment :—

Name.	Out-turn, sq. miles.	Approximate Number of Working Days
Capt. Trenchard, R.E.	239	10
,, Oakes, R.E.	328	10
Lieut. Huddleston, R.E.	400	15
Surveyor Hamid Gul	3,790	120
,, Bhamba Ram	1,333	50
,, Anwar Ali	250	20

At the close of the Abor Expedition rough outline and hill originals were prepared in Kobo while the detachment was awaiting demobilization orders at the beginning of April, 1912.

From these a provisional map of the surveys of 1911–12 was published in colours by the Map Publication Office towards the end of the same month.

By the end of September, 1912, all the computations had been finished and the outline sheet of the fair map was practically completed. (Blue prints of this outline sheet were used in 1912–13 for the re-survey and contouring of that area). The fair map of the Abor Expedition Surveys was not completed nor published however, as the Surveyor-General decided, when sanction for the operations of 1912–13 had been received, that publication should await the completion of surveys in that season.

Mention has already been made in para. 6 of this report of the explorations of Kinthup in the Dihāng Basin between 1881 and 1884.

As prominence has been given of late to the opinion of certain geographers that the geographical information which Kinthup supplied about the Dihāng Basin was merely collected by him in Tibet without visiting the Dihāng Valley and is therefore unreliable, this report seems a fit place to examine his work briefly in the light of the recent surveys carried out by the Abor Exploration party.

Firstly the accuracy of his names is very striking. In Pemakoichen and the Abor country he gives 57 names of which 34 fall within the area recently surveyed. Of these 34 names only 6 were not found; two being names of camps or caves, one a village since deserted, while the other three might well be known now under different names. Of the remaining 23 names which Kinthup gives beyond the area recently surveyed all except three were confirmed

by information obtained locally by the Political Officer in charge of the Abor Exploration party; two of the unverified names being those of caves and the third that of a pass.

Secondly, his description of the physical features of the different parts in which he travelled is remarkably correct. In the more intricate parts of this tangle of hills and winding rivers it was sometimes difficult to picture the topography from his account before actually visiting it, but, as a rule, it would be impossible to give a more accurate description in as few words.

Seeing that he was unable to keep a written record of his travels extending over a period of four years the accuracy of his account is remarkable. In the area recently surveyed he only appears to have made two geographical mistakes worth considering:—

(i.). Between Mobuk (or Gobuk) and Onlet (now known as Olon or Milang) Villages he mistook the Yamne Valley for that of the Dihāng.

(ii.). He stated that the river issuing from Sanga Chu Dzong joins the Tsan-po about 3 miles from Miri Padam.

As regards the first mistake anyone who has experienced days of continuous rain and mist among the intricate and often very deceptive hill features of the Abor country will realize how easy it is even for trained topographers to make such mistakes. Further it must be remembered that at this the most southerly point in his journey he was attempting to reach Assam and was following the direct trade route from Simong in the Dihāng Valley to Sadiyā when he was turned back by Padam Abors at Onlet (Olon or Milang) Village in the Yamne Valley. It is easy to understand how, after crossing the low saddle from Simong into the Yamne Valley he must have concluded that the river below him flowing south must be the same as the one he had just left. The second mistake appears to be the result of one of the few attempts he made to compile a topographical description from local information without actually visiting the ground. As this particular bit of information was obtained from Abors whose language he did not understand it is not surprising that he made this mistake. With these exceptions Kinthup made no serious mistakes.

Some of his critics, with the very insufficient knowledge of the Dihāng Basin obtained only in the Abor Expedition of 1911–12, have fastened on trifling details in his report in their attempts to prove that his whole account is purely imaginary.

One critic, for instance, maintained that there are no pine trees or apples in the Abor country as stated by Kinthup, and expressed his surprise that Kinthup should have omitted to mention Jido, a large Abor village near the junction of the Yang Sang Chu with the Dihāng.

Kinthup may not have known the different varieties of conifers, or may have been wrongly translated. One variety, the cypress, flourishes in many parts of the Abor Hills, and with the crab apple (eaten by Abors) has been found in most of the localities described by Kinthup. Jido Village was not built until three years after Kinthup had returned to India.

In short the theory that he must have ascended some high mountain in Tibet overlooking the Dihāng Basin from which all the villages on the Dihāng were pointed out and described to him, and that he merely committed all these names, details of routes, etc., to memory without leaving Tibet is utterly ludicrous, specially when advanced by those who have themselves visited even a small portion of this Dihāng Basin.

His account has been confirmed in the most remarkable manner and we are now able to establish Kinthup's claim to honourable record in the annals of the Survey of India, which he served with such zeal and devotion to duty.

The four views of the River Tsan-Po are from photographs by Captain F. M. Bailey, I.A., and are reproduced with his kind permission.

VIEWS

It has to provide for—

(*a*). Accidental defects in the material.
(*b*). Initial stresses in the material due to rolling.
(*c*). Stresses due to variation in temperature.
(*d*). Loss of section by corrosion.
(*e*). Faulty workmanship.
(*f*). Secondary stresses due to eccentric loading.

Taking all these probable causes of increase of actual as compared with calculated stresses into consideration, it does not appear that the nominal unit stress of 8 tons per square inch could be increased with advantage.

SECTION IV.—*Impact Formulas.*—All impact formulas are derived from Wöhler's experiments, followed by Bauschinger, Baker and others. Launhardt and Weyrauch deduced formulas from these. Mr. E. H. Stone has proposed a formula which expresses the ultimate effect of the moving load, building up his theory from the ratio which that load bears to the *total* load.

The Pencoyd formula as used by the Government of India depends more upon *span* than upon *range of stress*, thus differing from Stone's range rule.

The effects of the use of the various formulas are shown in diagrams.

SECTION V.—*The Evidence of the Immediate Effect of Moving Loads.*—(*a*). *By Calculation.*—One of the principal causes of increased stress, especially on small spans, is the periodical shifting of the weight due to the lurching of the engine. Variation of pressure is caused by centrifugal force set up by unbalanced parts or by excess vertical action of balance weights. An engine in use on the Bengal-Nagpur Railway is chosen for illustration, and increase of stress for spans of 5 ft. to 308 ft. is calculated for bending moments, shears and cross girders.

In addition, the causes of increased stress are—

(1). The effect of the velocity with which the load is applied.
(2). The effect of shocks caused by flat wheels, etc.
(3). The side pressure of the wheel flanges against the rails.
(4). Wind pressure on one rail.
(5). Coincidence of period of vibration.
(6). Curved trajectory of the moving load.

(*b*). *Experimental Evidence.*—Extensometer results of Messrs. La Touche and Sales, and Professor Turneaure, and deflection observations of the Government inspectors are plotted and examined in comparison with each other and with the Indian Government Rules.

SECTION VI.—*The Evidence of the Cumulative Effect of Moving Loads.*—The condition of 350 wrought-iron girders on the North Western Railway is shown in appendices detailing the result of tests.

of the material, and also in a drawing of a girder tested to destruction. After 30 years' use the girders had lost camber and showed loose rivets, and tests of the material indicated extreme brittleness.

The Lansdowne bridge, on the North Western Railway, after 24 years' use, has a large number of loose rivets. The stresses and typical joints are in illustrations. Corroborative evidence is given in a typical girder on the Bengal-Nagpur Railway.

General Conclusions.—Considering the sources of stress dealt with in Section III., and the evidences of the immediate effect of the moving load, the Author concludes that the minimum increment which should be allowed to the moving load is that which may be calculated by the formula—

$$I=\frac{50}{50+L}S \text{ as against the Government rule } I=\frac{300}{300+L}S.$$

This formula is suggested as a basis for discussion, as a suitable rule for use in connection with existing girders. For cross girders and rail-bearers even the Government rule is, if anything, too small.

For new girders intended to last indefinitely, it is doubtful whether the suggested formula is sufficient when taken in conjunction with the working stress of 8 tons per square inch.

Weight of Girders.—The weights of main girders to the existing rules, the modified rule $I=\frac{50}{50+L}$, and the Board of Trade Rules are calculated and compared.

REVIEW.

WHAT EVERY SOLDIER OUGHT TO KNOW.

(Humphrey Milford, Oxford University Press. Amen Corner, London, E.C.).

THIS little work consists mainly of extracts taken (by permission of the War Office) from official text-books and training manuals, and is an attempt to provide the private soldier with as much knowledge of his profession as may conveniently be conveyed in print and in the smallest possible compass. Care has been taken to preserve the spirit as well as the letter of the authorized books of instruction. The text-books, etc., from which the information has been derived include The King's Regulations, Manual of Military Law, Field Service Regulations, Field Service Pocket Book, Manual of Field Engineering, Manual of Map Reading, R.A.M.C. Training, and the Manual of Military Hygiene, so it is very comprehensive. It is principally intended for the use of N.C.O.'s and men, is of a handy size, $2\frac{3}{4} \times 4\frac{3}{4}$ in., and the price is twopence.

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