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CONTENTS.

	PAGE.
Organisation of the Railway Department in War. By Capt. J. W. S. SEWELL, R.E.	1
munications. By Capt. J. E. E. CRASTER, R.E.	6
periments on Road Surfaces. By Bt. Col. H. de H. HAIG, R.E.... ...	10
toric Influence of Foreign Policy on Coast Defences. By Bt. Col. O. E. RUCK, R.E.	12
our Ideas on Permanent Fortification up to date? By Major H. E. G. CLAYTON, R.E. (*With Plates*)	20
Engineers of the German Army. By Col. J. A. FERRIER, D.S.O., R.E. ...	28
script:—Exploration and Survey with the Tibet Frontier Commission, and from Gyangtse to Simla *vid* Gartok. By Major C. H. D. RYDER, R.E. (From *The Geographical Journal*). (*With Photos and Map*) ...	53
view:—*The Life of Sir Andrew Clarke.* By Col. R. H. VETCH, C.B., late R.E. (Col. E. S. E. CHILDERS, R.E.)	71
tices of Magazines	78
t Publications	80

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CONTENTS.

PAGE.

1. THE ORGANISATION OF THE RAILWAY DEPARTMENT IN WAR. By Capt. J. W. S. Sewell, R.E. 1

2. COMMUNICATIONS. By Capt. J. E. E. Craster, R.E. 6

3. EXPERIMENTS ON ROAD SURFACES. By Bt. Col. H. de H. Haig, R.E. ... 10

4. HISTORIC INFLUENCE OF FOREIGN POLICY ON COAST DEFENCES. By Bt. Col. O. E. Ruck, R.E. 12

5. ARE OUR IDEAS ON PERMANENT FORTIFICATION UP TO DATE? By Major H. E. G. Clayton, R.E. (*With Plates*)... 20

6. THE ENGINEERS OF THE GERMAN ARMY. By Col. J. A. Ferrier, D.S.O., R.E. 28

7. TRANSCRIPT :—
Exploration and Survey with the Tibet Frontier Commission, and from Gyangtse to Simla *vid* Gartok. By Major C. H. D. Ryder, R.E. (From *The Geographical Journal*). (*With Photos and Map*) 53

8. REVIEW :—
The Life of Sir Andrew Clarke. By Col. R. H. Vetch, C.B., late R.E. (Col. E. S. E. Childers, R.E.) 71

9. NOTICES OF MAGAZINES :—
Engineering Record. By Capt. C. E. Vickers, R.E. 78
Nature. By Major-General W. E. Warrand, D.L., late R.E.... 78

10. RECENT PUBLICATIONS... 80

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The Expedition crossing the Brahmaputra at Chaksam.

Bridge over Nyang Chu near the Mission Post.
Gyantse Dzong in background.

Shigatse Dzong

The Source Of Tsang-po (Brahmaputra)

THE ORGANISATION OF THE RAILWAY DEPARTMENT IN WAR.

By Capt. J. W. S. Sewell, R.E.

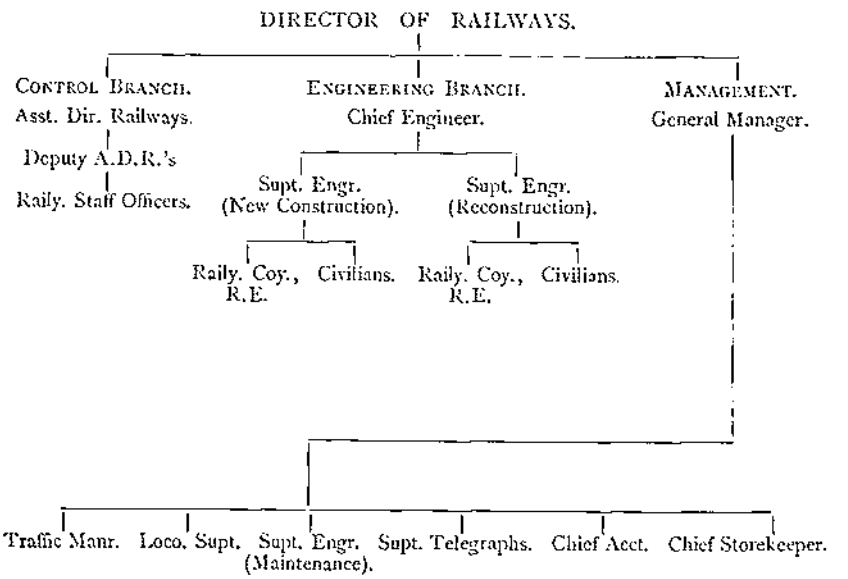
The Organisation of the Railway Department in War constitutes an interesting study for the R.E. officer, inasmuch as it presents many of the conditions to be met with in the war organisation of the Corps generally.

When the principles of such an organisation are laid down in peace, the system chosen must be of a sufficiently elastic nature to be altered without difficulty to meet the varying conditions of British campaigns. The history of the construction of such a system is given in detail in *The History of the Railways in South Africa, 1899—1902.* But it is somewhat obscure to the casual reader, and this article is an attempt to formulate the results and to deduce the lessons contained.

Previous to 1896 the British army had no practical experience of any value in the use of railways in war. In the years 1896–99 the Soudan Military Railway was constructed and worked by R.E. officers. The lessons then learnt and those taught by the Franco-Prussian war of 1870 were applied in the administration of the railways in our South African war of 1899—1902, until a system was evolved that may well be regarded as a model for future campaigns. This organisation had to deal in a greater or less degree with all the more important problems which could confront a Director of Railways. These are (*vide* "Railways in War" by Sir Percy Girouard, in *R.E. Journal,* July, 1905) :—

(1). The control of railways in a friendly country worked by a friendly staff.
(2). Reconstruction ; that is, the repair of damaged lines.
(3). The construction of a new railway or railways.
(4). The working of railways in a hostile country.

Any or all of these duties may have to be undertaken. It is therefore best to frame the requisite organisation for the maximum work required. It can then easily be modified to meet the requirements of any special case. The following Table gives a general idea of such an organisation.



It will be noted that in the Table consideration of detail, such as control of finance, etc., is omitted. Furthermore, varying conditions will of course modify the system. For example, the D.R. might personally direct the control branch, or act as General Manager of the working branch. Again, the importance of the engineering branch will, as time progresses, vary inversely as that of the working branch; it may well happen that the engineering branch can be put at once under the G.M., and a time will certainly come when this must be done. But the principles will remain unaltered as regards the employment of the railway units and R.E. officers.

Let us consider the case of the Railway Companies, R.E. In the above system we see the relegation of these units to their proper function:—construction work. Until lately the objective in view in training these units appears to have been their expansion in war into an administration to construct, maintain, and work a 2′ 6″ steam tramway. Recent campaigns have shown this to be too restricted a view, and have assigned to the railway department a far more ambitious *rôle*, in which the steam tram plays no part.

In a Railway Company in future campaigns we shall need a few specialists to work the small section (in advance of the furthest open station) which is in charge of the construction engineer and has not yet been handed to the management of the open lines, and also to find the technical staff for armoured trains. The remainder must be "construction" sappers. In peace there is a tendency towards the sapper working too much at his one trade. We want "handy" men: as one officer puts it, "we want one trade in the Corps,—that of making things." It would, I fear, be considered heretical if it were

suggested that the rank and file of the Corps should be rated as sappers; but were this done, it is at least doubtful if it would affect either recruiting or our standard as much as is sometimes suggested,—bearing in mind the very excellent pay and advantages now offered. A company of specialists is economically unsound as is the recognised fact with a small workshop: for only a portion of the trades are of use at any one time. Handiness is essential in the railway sapper.

Experience has proved that the military qualities and discipline of the R.E. regulars are essential for front line construction or re-construction work; but the finishing touches, of the nature of permanent bridges, buildings, etc., can be put on in rear of the front line and, where the communications are reasonably immune from hostile attack, by corps of civilians or specially enrolled troops. In countries where coolie labour exists such labour will be utilised to assist the sappers by performing the unskilled labour for them.

Before leaving the subject of railway construction it is necessary to mention the use of tramways. As an introduction to this it is expedient to digress for a moment to discuss a matter which does not appear to be clearly understood by some officers, viz.:—gauge. Distinction must be made between a railway and a steam tram. The contingency of the latter ever being required, even for some very local purpose, is remote in any case, and a branch railway or siding would usually be far more useful. To avoid breaking transit the gauge of the country must be adopted if railways already exist. In the few cases where they do not exist, and where it is improbable that connection will ever be made with any existing system, various factors have to be considered and balanced:—

(1). The possibility of rapid construction.

(2). Maximum train loads are essential factors. The load will increase nearly as the cube of the gauge, but a restriction is imposed by the necessity for rapid construction.

(3). Existing rolling stock must be available in large quantities. There are practically four standard gauges:—5′ 6″ (India), 5′ 0″ (Russia), 4′ 8½″, and 3′ 6″. For the 5′ 6″, 4′ 8½″, and 3′ 6″ gauges rolling stock would always be available, and perhaps for a mètre gauge. As the construction of rolling stock is a slow process, building a railway for which existing rolling stock is not at once available would be similar to engaging in a naval war without having first acquired a fleet.

The conception of a steam tram presumably arose from the idea that a narrow gauge was necessary for siege purposes; but here again a branch line of normal gauge would probably be more advantageous (*vide* "Railways in War" quoted above). There is however a distinct use for a horse tram. When an army halts for any period in excess

of three or four days on such a frontage as (say) 30 miles, the flank corps will be at a distance from rail-head that would be most exhausting to supply columns resorting thereto to replenish their stocks. It might then be advisable to bring up a very light "Decauville" tramway, 18" or 2' gauge, with 14-lb. rails and light trucks: this could be laid rapidly across almost any country in a manner and on grades which, while not permitting the use of locomotives, would enable trams to be drawn by animal transport, thus obviating exhausting haulage of wagons along (probably) indifferent roads. The work of laying such tramways should be entrusted to the Field Engineers.

The employment of R.E. Officers may now be considered. It is an axiom that in war a surplus of R.E. officers is required. In peace state employment is found for such officers,—in our army in fortification and barrack maintenance work. It is perhaps unfortunate that the necessary circulation of officers and the consequent rotation of duties, whilst tending to produce a "handy" officer, militates against "specialising." Generally speaking, in fact, there is as much tendency for an officer to be handy at the expense of specialisation as there is for the sapper to be a specialist at the expense of handiness. Be that as it may, the necessity is here apparent for the supply in war of specialist railway officers from the surplus. They would be sent out as special service officers, not as extra officers of railway companies. In the above organisation there is room for a number of such officers: to mention only a few—the Director, Assistant Director, and some of the Control staff; the Chief Engineer and his subordinates; the General Manager and his Loco. Supt., Supt. Engineer, Supt. Telegraphs, and other junior officers.

To recapitulate, there is a R.E. officer at the head of the department, with a staff of special service R.E. officers, and with R.E. companies in the first line (on the Lines of Communication), and a second line of civilian or quasi-military corps.

It is interesting to consider what would be the effect of introducing an analogous war organisation for the R.E. generally. If such a system could be adopted for the Field Engineers we should have a large supply of extra R.E. officers sent out to the Chief Field Engineer in such numbers as might be necessary for the campaign in hand. These officers would then be "in hand" for use as required; whereas, if they are told off beforehand to Divisions or as extra officers for R.E. units, there may easily be a surplus at one point and a deficiency at another where they are badly needed. In South Africa there appeared to be some consensus of opinion that there were too many R.E. officers with (for example) an Infantry Division; whilst certainly on the L. of C. the junior officers in the early part of the war were frequently in need of the control and support of a senior.

There is on the L. of C. a mass of engineering work to be done in

preparing or superintending the defences, water supply, etc., of camps, stations, and posts, the maintenance and improvement of communications, and the erection of semi-permanent buildings, such as hospitals, huts, bakeries, remount buildings, etc. The hasty work of the front line, such as temporary bridges, field engineering generally, field telephone communications, and field tramways, will vary so much with the nature and locality of each campaign that the principle of fixing the numbers of R.E. in the front line by the number of infantry would seem worthy of reconsideration. Under a system similar to that adopted for the railway department, only such R.E. units would be sent forward at first into the front line as the nature of the campaign required, the remainder being allotted to Sections of the L. of C. These latter units and a second line of civilians, under C.R.E.s of Sections, would carry out the more permanent work indicated above.

COMMUNICATIONS.

By Capt. J. E. E. Craster, R.E.

Once upon a time an eminent authority gave it as his opinion that tactics changed every ten years. Had this rate of change remained constant, tactics would now be reckoned among the most immutable of military affairs. The statement however was made at a period when the weapons employed changed but little, and when consequently there was no obvious reason for a change in tactics unless it was brought about by a variation in the quality or number of the troops employed or in the skill and experience of their leaders.

In modern times weapons improve so rapidly in range, accuracy, and rate of fire that a rifle or gun is obsolete in one or more of these qualities almost before it leaves the arsenal. All these improvements necessitate correspondingly rapid modifications in tactics, but it is to be feared that the tacticians are not able to keep pace with them. The theory of tactics does not alter much if at all, it is the practice that becomes each year more circumscribed; every year movements that used to be easy become difficult; what is difficult to-day will to-morrow be impossible. It reflects little credit on the imagination or forethought of tacticians as a whole that every new fire effect has caught them napping; although the quality of each new weapon is accurately and widely known, the modifications in formations and manœuvres that its adoption must produce are rarely foreseen, never provided for.

If we go back a hundred years and compare the parts played by the commander of a force then and now we shall appreciate what great modifications modern developments have produced even in this one *rôle*. Accounts of the campaigns of the last century do not give us many glimpses of the great commanders during the actual progress of their battles; but on the few occasions when they are visible through the clouds of smoke they are nearly always occupied in the same way, namely in personally supervising the movements of their troops; apparently it was their normal occupation. Sometimes we discover them leading the general reserve to deal the decisive blow, sometimes they are withdrawing men in ones and twos from the less threatened portions of the line to organise a local counter-attack.

It is clear that the dispositions of the troops were perpetually modified and adjusted by the commander in person to suit the exigencies of the moment. This was an ideal state of affairs, but it

cannot be approached under modern conditions; the forces engaged are too large, the extent of the battlefield is too enormous, the intensity of modern rifle fire is too deadly, for the principal commanders or their staff officers to ride hither and thither and arrange the troops to their liking.

Modern developments have driven the Commander-in-Chief off the battlefield. He will probably be found in a quiet country house miles from the scene of action, and the only external evidence that this house contains the directing power of the army will be the large number of telegraph and telephone wires radiating from it. The days when a Commander-in-Chief could lead the final cavalry charge have gone for ever. The commander of any considerable force who takes a personal part in the fray forthwith abandons his command. His action is not war; it is not even magnificent.

However this is neither the place nor the time to lay down what a commander shall and what he shall not do. The above arguments were brought forward to convince the reader that the old *rôle* is impossible, so that he might more readily acquiesce in the development of the new. If a commander is to keep in touch with all the component parts of a vast army distributed over anything from twenty to a hundred miles of country, it can only be by the help of a network of telegraphs and telephones. It is the duty of the Engineers to arrange the system and to maintain it in working order; on us now depends the connection between the brain and the body of an army, and the exclusion of the commander from the battlefield has enormously added to our burden of work and responsibility.

The closer we approach to the firing line the more difficult becomes the transmission of orders, until at last we arrive at a point where, even if orders can be conveyed to the troops concerned, it is almost impossible for them to carry out any movements whatever. The development of artillery and rifle fire has deprived troops within the fire zone of most of their manœuvring power. Where the fire is most intense they must lie motionless throughout the day; in more favourable positions they may be able to crawl about a little and to advance or retire by slow degrees; but to manœuvre, in the old sense of the term, within range and view of the enemy is impossible.

Yet this lost power of manœuvring can to some extent be restored by artificial means and by taking advantage of natural cover. Complete mobility and secrecy can only be ensured by continuous cover from view; cover from fire is of no immediate tactical importance, and we may regard it, for the present, as merely a concession to the craving of the individual for personal safety.

Where the personal element is eliminated we find screens of cornstalks erected instead of earthen parapets. Such cornstalk screens, erected under the supervision of the Japanese General Staff, had a great tactical value because they served to mystify and mislead the

enemy; they were objects of little interest to the individual Japanese soldier because they would not stop a bullet.

The battle of Mukden, however, gives us an example of a form of cover which had little tactical value but which was an object of great solicitude on the part of one individual. A Japanese soldier went into battle carrying a Gladstone bag filled with stones. The fact that it was portable, and therefore did not destroy the mobility of its owner, did give it some slight tactical interest and rendered it far preferable to a shelter trench; there however its tactical value ceased; its individual interest lay in the fact that it was bullet-proof. Unfortunately the owner of the bag did not survive the battle. Whether he was shot as he peered round the right-hand bottom corner, or whether the bag finally let a bullet through, or whether he met his fate as he advanced bag in hand, history does not relate.

The point to be illustrated and emphasized is this:—Cover which has only a tactical value must be thought out and arranged for by the Staff, more particularly the Engineer Staff, otherwise it will be neglected; cover which is of immediate and obvious value to the individual will be arranged for and provided by the troops themselves after they have been under fire a few times. Seasoned troops will spontaneously entrench themselves, but they cannot be expected to make or arrange for covered communications on any adequate scale; this is the business of the engineers.

The increasing range and accuracy of modern weapons render the necessity for covered communications every day more urgent. A general can ask for no greater boon than the power to reinforce or withdraw his troops, unobserved and unmolested by the enemy, at any and every point along his position; and conversely his chief desire must be to deprive the enemy of this power.

Doubtless all the readers of this *Journal* know by heart the twelve chief requisites of a defensive position as stated in this year's *Combined Training;* and they will remember that the seventh on the list is:—"Sufficient depth and good lateral communications in rear of the entrenchments, so as to allow the covered passage of troops to any desired point."

It is a pity that all the twelve requisites could not be numbered "one," for though they may not all be equally important they must all be considered together; above all the question of communications must not be left to the last. Troops armed with modern rifles can hold almost any ground if they are properly entrenched; in selecting a position it is therefore possible to allow the question of communications more weight than formerly. Unless you consider your lateral communications from the very first you will neglect them; if you neglect them then, when the pinch comes you will find your troops are earthbound, divided and helpless, unable to concentrate for either attack or defence, caught like rats in a trap, to be exterminated at

leisure by your victorious enemy. An isolated length of shelter trench bears more than a superficial resemblance to a grave.

This is an additional reason why this subject should receive the particular attention of military engineers. The chief drawback to the use of field defences is that they tend by their moral effect to render the troops using them immobile; if in addition the communications are faulty, the works may form very concrete obstacles to mobility. It is essential that the engineer should recognize this tendency and combat it by every means in his power. Works designed by him or executed under his supervision should, by the completeness of their communications, become aids to mobility and obstacles only to the enemy.

The question that has inspired this rambling and disjointed discourse is this:—how to restore to a modern force its lost mobility; how to preserve it as a mobile and coherent body, so that it may fight, manœuvre, and fight again as long as human endurance render movements and fighting possible. The answer to this question is good communications. Communications include telegraphs, railways, roads, trenches, and screens; all these are, for the present at any rate, in our charge. An inexorable destiny—nothing less, in fact, than the advance of civilization—is placing the 'ordering' of the battle more and more in the hands of the engineers. It is for us to recognise that destiny and to prepare for it; nothing that calculation or forethought can supply must be left to chance.

EXPERIMENTS ON ROAD SURFACES.

By Bt. Col. H. de H. Haig, R.E.

The dust and mud on the roads about Brompton Barracks, Chatham, have long been a source of annoyance, which called for some remedy. Experiments have therefore been carried out recently with a view to improving road surfaces, and to making them suitable for all sorts of traffic.

As the road passing the Institute was being re-made at the lower end, the opportunity was taken to carry out a series of trials to ascertain what is the best material to bind the surface and throw off water.

(1). The first thing tried was Westrumite, which has been much advertised for the purpose. £10 was spent on its purchase, and £10 more for sprinkling it over an area of about 1,200 square yards. The result was not satisfactory. It did lay the dust almost entirely at first; but the effect very soon wore out, and in two months' time one could not tell that it had ever been applied.

(2). Next a piece of road, about 500 yards long and 30 feet wide, was bottomed with 6 inches of large stones and brick burrs, and then covered with 4 inches of broken granite, 2-inch gauge. This was rolled, without any binding material whatever, until the whole surface was thoroughly hard and smooth, the steam roller making no impression. Then a mixture of tar and creosote, in the proportion of 30 to 1, was heated and poured over the surface, being broomed into the interstices; this made too liquid a mixture, so the proportion of creosote was reduced by two-thirds. The tar was allowed to set for four days, and the surface once more rolled with the steam roller. The result appears to be excellent, but the cost was somewhat extravagant, being 1s. 9d. per yard super.

(3). An experiment was then tried with a road surface that had already been made in the ordinary way, with similar (but deeper) soleing and crushed granite, but filled in with fine pit gravel; this portion had been in use for over a year, and had been subjected to very severe traffic from traction engines twisting round a bend. The surface was first swept with hard brooms down to the crushed granite. Then a mixture of pitch and tar, in the proportion of 1 lb. pitch to 10 gallons of tar, was heated and poured on, being brushed in with hard brooms. It was found that this took too long in setting, and on hot days was inclined to lift. The proportion of pitch was then

increased to 1 to 8 of tar, and some road sweepings were added for the surface. This answered for ordinary traffic; but under the steam traction engines the surface became scaly and inclined to peel off.

A mixture of 1 lb. of pitch to 5 gallons of tar was finally tried, and some road sweepings were used as a covering during the setting, the spare material being swept off on the second day. The result of this appears to be perfectly satisfactory under all traffic; there is no dust or mud, and the surface dries very quickly after rain. How long it will last cannot yet be told, but it promises well under traction-engine traffic. The cost works out to only 2½d. per square yard, which could be considerably reduced if operations were on a large scale, and proper cauldrons were available for boiling the mixture. The important condition is that the surface must be thoroughly cleaned, and the mixture put on whilst it is quite dry so that it gets a firm grip.

HISTORIC INFLUENCE OF FOREIGN POLICY ON COAST DEFENCES.

By Bt. Col. O. E. Ruck, R.E.

That the progress of defence works has always been subject to fluctuations, both in regard to design, and also as to cost of maintenance—varying in direct proportion to the supposed strategical and economical necessities of the times—is amply proved by a cursory glance into the far-away pages of our country's story.

In some cases the invading enemy were underrated, the defences being afterwards found to be inadequate ; in others the reverse took place : but they were few.

For the purpose of this retrospect, it will not be necessary to probe too deeply into the records of the past, nor to conjure up, in imagination, works of fortification not in evidence at the present day.

A brief study, on their actual sites, of the Celtic and Brigantian hill forts now in existence in England and Scotland, constructed even so late as 55 B.C., will at once shew that either the strength of the Roman invaders was undervalued, or that time and means were not available to hand for greater efforts on the part of the defenders.

Again, the stern lessons of bitter experience—gained, as a rule after, and not before the event—determined the scale on which the strength of Roman defence works and the expenditure involved eventually had to be based.

From a study of the works themselves, we know that Agricola in 81 A.D., with a view to confining the Caledonian tribes within prescribed boundaries, built 16 detached forts of aggested earth between the estuaries of the rivers Clyde and Forth.

After-experience, however, soon proved that the original works were underestimated in point of strength ; the Caledonians, as time went on waxed exceeding troublesome, and the task of revision remained for completion by Lollius Urbicus, who, in A.D. 144, by the addition of a continuous rampart with fosse, 34 miles in length, appuied with the early forts of Agricola—now strengthened by masonry—brought the whole of the defences up-to-date. The cost of this revision amounted to some £250,000 at current civil rates of wages. The same under-estimate of works, urgently required on the part of an invading army which meant to remain in possession, was again made by Hadrian in A.D. 120, whilst engaged in raising his wall

of forts and continuous lines between the Solway Firth and the mouth of the Tyne, a distance of 72 miles.

Owing to an unforeseen development of the strategic situation, the Meatœ tribes having joined forces with the Caledonians, a revision of the whole lines had to be made by Septimius Severus in the year 200 A.D. at an approximate cost of ¾ of a million sterling.

Coming farther south, the British defences at Dover, which commanded the antient harbour and proved sufficient to deter Julius Cæsar in B.C. 55 from landing at that place, had afterwards to be strengthened by the Romans themselves, as a necessary precaution against the depredations of the pirates of the North Sea, the Jutes, the Angles and the Saxons.

Scarcely had the Romans turned their backs on this country, when the latter people in their turn strengthened the defences against a probable Norman invasion by sea, adding thereto an outer Vallum and Fosse.

Then again the Normans, after turning and taking the defences of Dover from the land side, previously having landed at Pevensey, commenced forthwith to yet again strengthen the works in view of the next probable attack, whether it came from the land, or from the seaside ; the chances of either form of attack appearing to be about even.

In A.D. 1135—1154, Stephen being king, an insurrection in Scotland and Wales, followed by a general state of anarchy consequent on the creation of an excess of earldoms, and the building of innumerable strongholds by castle-building Barons, led to more increasing of the defences of Dover by those already in possession ; the attack which inevitably followed happened to be a combined land and sea attempt by a landing force under the Dauphin Louis of France, operating from without, aided by rebellious but more or less friendly Barons intriguing from within. This fight took place in 1216 and ended in the defeat of the attackers and their friends.

In 1223, the sum of £2,923 was spent on improved works at Dover by Henry the Third and the defences were still kept up to strength, but in 1295 their efficiency was again put to the test by a raiding force of fifteen thousand Frenchmen under Montmorenci who were put to flight.

Edward the First set great store by Dover in view of the war necessitated by a Franco-Welch-Scottish alliance in 1296. Troubles with France in the reigns of Edward the Second and Edward the Third eventually landing us in a naval defeat off Rochelle in 1372, led to much work of revision on the Dover defences, large sums being expended of which a minute record is still preserved in the public record office.

From the year 1339 up to 1483 there had been ten raids on the national defences by the French, these defences as a whole having

been unwisely allowed to fall into comparative desuetude, thus courting attack.

It is not therefore surprising, that when Henry the Eighth entered on the scene in 1509 and engaged in military operations with Louis the Twelfth in the South of France, two successful raids were meanwhile made on the coast of Sussex by Prior John, in the course of which the English artillery was found to be outranged by that of the French. The energetic Henry at once turned his personal attention to a general strengthening of the Coast Defences of the realm; and particularly to the improvement of Ordnance, in view of future eventualities. So successful and farsighted was he, that the next French raid in 1545 on Portsmouth and the Isle of Wight was repelled by means of these new defences erected by Henry as a matter of prudence.

Amongst the many coast Ports strengthened by him were those of London and the Thames, including Gravesend Bulwark, Milton and Higham Bulwarks, East Tilbury Castle and West Tilbury Blockhouse. The increased strength of the defences constructed by this vigorous and prudent monarch effectually checked any further attempts by serious raids for more than a century.

The insurance policy thus effected by Henry, and paid for in great measure from ecclesiastical funds on the suppression of the Abbeys, sufficed for the requirements of the country during the reigns of Edward the Sixth and Mary, little or nothing being done for the defence of the coasts.

But when Queen Elizabeth came to the throne and England found herself at war with the second power in the world, the country slowly aroused itself to a conviction, that some active steps towards improving the state of the defences would be worthy of being taken into leisurely consideration.

The previous reigns had been those of great extravagance and waste, so much so that, with the financial pressure which was always weighing over England, the supplies and fortifications of Calais had been shockingly neglected and the loss of that port in 1558 inevitably followed.

In 1587, nineteen years after the accession of Elizabeth, the Round Tower at Portsmouth was reported to be so old and rotten that it was dangerous to shoot from; the forts at Gravesend and Tilbury were nearly as bad, for in July 1588 (the Armada almost in sight) we find that "there was not one platform fit to bear any Ordinance, neither on the ground nor aloft"; on the following day, however, we read that the inspecting officer "has putt these Fortes in as good strength as tyme wyll permytt."

Three years after the accession of Queen Elizabeth the Bulwark at Upnor was completed and by 1561 some form of defence existed at Queenborough and Sheerness.

In 1580, owing to the descent on Smerwick in Kerry, by Spanish and

Italians assisting the Irish Catholics now in rebellion, emergency orders were issued that three forts must be made at Milford, viz., at Rat Island, Dale, and Stack Rock, "to be set in hande at one instante, and great expedition used upon them."

But, as is so often wont to occur at a crisis and when hasty work is required, it came to pass that no experienced fort builders were surviving. In the decadence of defences in the preceding two reigns "the cooks from long disuse forgot their trade," and fortifications according to the prescription of an Italian gentleman named Frederick Genebelli were erected to replace what had now become a lost art in our own country.

Twenty years had passed by, Elizabeth being Queen; but beyond the commencement of the defences of the Medway, and those of Milford Haven, little else had been attempted in the military works line.

In July, 1588, the English nation, relying on these new works as yet in their infancy, and also on partially patched-up forts of Henry the Eighth's time, awaited with contemptuous confidence the denouement of events; the end of the month saw the stately advance of the Spanish Armada, which, as we know, by a most fortuitous combination of circumstances was destined to ultimate dispersal and partial destruction.

The immediate crisis having passed, the next eight years afforded a short breathing space for consideration and action if so desired; but in the year 1596 a second invasion from Spain loomed up at an earlier date than was anticipated, forcing the pace, and disturbing the prevailing equanimity. Some show of action was now attempted; the Privy Council after a short deliberation issued an important Report on the "application of the wise proceedings of our ancestors to the present crisis of public safety."

This report, issued for the private information of members of the government only, at once raised a veritable maelstrom of controversial discussion carried on by Amateur Experts in public, as to which of the many undefended ports should be strengthened first, and whether any other places in their vicinity required fortifying.

Time still continued to go on, and by 1603, James being king, peace came with Spain, followed by a further decadence in the military efficiency of the defences of England; that is, until the year 1623, when, almost in the twinkling of an eye, war with Spain again appeared as a possibility to be reckoned with at an early date.

Immediate surveys were forthwith made as to the necessary repairs required to render the forts and armaments efficient, but no funds appear to have been forthcoming from the exchequer, even in spite of reiterated warnings and reports that none of the existing Forts were expected to survive the winter.

In 1625, Charles the First had mounted his throne, and the same

complaints as to the need for revision of Henry the Eighth's constructions continued. Thus it arose, in 1627, rumours of war with France being to the fore, that the town of Dartmouth, tired of waiting for decisions, in their corporate capacity and of their own volition built themselves defences out of the rates, and further applied for powers to purchase guns to arm the same.

The military energies of the period were, however, too much absorbed in the contests of the civil war for the nation to devote much attention to coast defences, in the absence of threatening foreign attacks.

On the accession of Charles the Second in 1660, Sir Bernard-de-Gomme, a clever French military Engineer, with leanings in the direction of the Dutch School, was appointed Chief Engineer of all the King's Castles in England and Wales and commenced to revivify some of the decadent coast works already in existence. The essential element of time was however required, so that when, in the year 1666, a bolt from the blue in the unwelcome form of a war with France, Denmark and Holland suddenly appeared, it can readily be believed that in the words of Macaulay "The House of Commons willingly voted sums unexampled in our country's history" for improving old works of Coast Defences and hastily erecting new ones.

The last-mentioned descriptive method, that of "hastily erected improvised works," which has so soothing a sound to the parsimoniously inclined or the procrastinator, and which reverberates in our ears with a somewhat familiar ring, is no newly coined aphorism. Hastings in 1557 being reported as "easy to fortify at any time from its strong position," whilst in the same year the Isle of Portland "is so strong by nature that it should easily be made impregnable in a short time, by the help of a little art." Both these places could therefore well be left for future consideration.

The years 1666–7 were especially instructive, as the British Fleet was "in being," but unfortunately chiefly on paper. Charles the Second, who at the time was secretly receiving from Louis of France the sum of £200,000 a year for the privilege of acting as that king's vassal, according to Pepys "took the fatal resolution of lying up his great ships, and keeping only a few frigates on the cruise."

The public records of the period refer to the strenuous exertions made by the people, with the aid of the chief engineer Bernard-de-Gomme, to crowd into as short a time as possible as big a programme of fortifications as could be devised; including chiefly the East, South, and North-East coast defences. Doubtful Naval victories were being won alternately by the Dutch and English, and whilst negotiations for peace were in progress at Breda, De Ruyter seized the opportunity to make his famous raid on the Thames and Medway Defences; the Dutch becoming virtually masters of the mouth of the Thames and English Channel for the space of six weeks.

This memorable raid commenced on the 9th of June, 1667, by 18 light ships and frigates with 1,000 men ascending the river Thames with the object—not, as is supposed by some, to vent their spleen on the sleek and well-nourished citizens of London—but to surprise some English ships which were reported to have sought security in the upper reaches.

On the 10th, the Dutch vessels being anchored off Hole-Haven tide and wind against them, some of the crews, strictly against orders landed on Canvey Island, stealing some sheep, and burning some insignificant barns; the same afternoon the ships weighed anchor and dropping downstream fell back on Sheerness, destroying the forts (such as they were), as well as the warships almost destitute of ammunition (which had been demanded but not yet received in full). The next day the Dutch proceeded upstream in the Medway to Upnor and Chatham, burning the *Royal James*, the *Royal Oak*, and the *Loyal London*; the *Royal Charles* they took away, running her on the mud, eventually sending her to Holland for exhibition purposes. Afterwards, the Dutch fleet went on to Harwich, stole more sheep from the lower Hope marshes, battered East Tilbury church, fought an action in the Hope with nineteen improvised on-the-spur-of-the-moment ships, which according to Brandt "set the river ablaze"; and then on the 23rd of July again went off to Harwich, where, after varying the monotony of their stay by sundry diversions of a sporting character, they remained until the declaration of peace in the end of August, 1667. What appears, at first sight, to be of rather startling a nature, having regard to the admittedly highly strung temperament of our congested town-dwellers at the present day, is the alarming effect this purely Naval raid produced on both the urban and also on the rural population of this country.

On the 9th of June, when the Dutch fleet had commenced to silently glide into the approaches of the Thames as far off as Ramsgate, Evelyn states "The alarm was so great, that it put both country and city into fear, panic, and consternation, such as I hope I shall never see again. Everybody was flying: none knew why or whither" Pepys, living in London, at once took steps to realise his property in hard cash, and sends his wife into the Hinterland with £1,000 in coin which she is instructed to bury in some secluded nook. On the 15th of June, the Dutch fleet lying quietly near the Nore buoy formulating fresh enterprises after the raid on Chatham, a city man writes "The Marchants are undone; Our great Banckers of money have shutt upp their shoppes. People are ready to teare the haires from off their heads. Wee expect the Dutch as far as Woollage; All the people are fled from Greenage and Blackwall with their families and children."

On the 17th of June, the day before the Dutch detached one of their three squadrons to raid Harwich and Aldeburgh, the feelings of

the landsmen were somewhat chastened, for they report "these are sad and troublous times" "Ill news comes so thick that we are not able to keep up the spirits of the people; indeed we ourselves are so dejected that we can hardly conceal it." Pepys feared that the mob might burn his office and do personal violence to himself, owing to his connection with the Navy. It was reported generally that all the King's ships at Chatham had been burnt (whereas most of them were uninjured). Some said "The King was gone out of town, nobody knew whither," others, "that he was gone out of this life and (out of the world)." There were rumours that Harwich, Colchester and Dover had been burnt out by the Dutch.

This undignified scare, short and sharp as it was, soon subsided into the oblivion of the past. In James the Second's reign, 1685—1688, little or nothing was done to keep up the defences. William the Third contented himself by perpetuating his name in the erection of Fort William in order that he might overawe the Highlanders. In the times of William and Mary the usual perennial threatened invasion by the French was checkmated for a period by the Naval victory at La Hogue by Admiral Rooke in 1692, and Coast Defences were at a discount.

Pass we now to the days of amiable Queen Anne.

In the middle of this Queen's reign, chiefly owing to a projected invasion of England by the King of France, acting on behalf of the Scottish Pretender, great preparations were made for the extension of the fortifications, that is in so far as the necessary land was concerned; but the crisis passing away, no Forts were commenced. The next works of importance that were constructed took place at Chatham and Devonport in the reign of George the Second; the immediate cause being reported to have arisen by the reason of the "urgent and hostile invasion made on his Majesty's dominions in America and the Mediterranean, and the great preparations made in France for invading these realms."

In the reign of George the Third more additions were made, but for the most part they were allowed to fall into decay after the war.

Between 1790 and 1860, the year when a Royal Commission was appointed to enquire into "the present state, condition, and sufficiency of the fortifications existing for the defences of our United Kingdom," little was done beyond executing the necessary repairs.

The perusal of the historic examples enumerated, and any others which may have been omitted, invariably tell the same recurring tale, pointing as they do to the unerring sequence of a policy of close parsimony followed by lavish ill-considered and hasty outlay with regard to our Coast Defences. Great risks were continually being run during times when a happy-go-lucky, hand-to-mouth policy, chiefly due to motives of economy or greed, had permitted matters of defence to drift on, regardless of danger; the fates, on the whole, had been curiously

propitious. The number of regrettable incidents had been large; but fewer, it is true, as time went on, owing to a steadily growing conviction that an all-powerful Navy combined with strong home defences were absolutely necessary for true economy; and also to give that freedom of action so essentially required by a Navy and Army "in being" for operations over and across the seas. Likewise as a means of preserving that peaceful security to society inhabiting these Islands, necessary for the uninterrupted flow of the world's commerce, to save disastrous pecuniary losses due to dislocation of business, and finally to obviate the degrading attitude of undignified frantic panic, which the unorganised, undisciplined civil population would be naturally inclined to adopt at a time of sudden attack or unexpected raid.

ARE OUR IDEAS ON PERMANENT FORTIFICATION UP TO DATE?

By MAJOR H. E. G. CLAYTON, R.E.

SIR GEORGE CLARKE in *Fortification: Its Past Achievements, Recent Developments, and Future Progress*, published in London, 1890, states on p. 131 :—"Full development of rifle fire implies the abolition of traverses (which in works of the type advocated, Twydall Redoubt, are practically useless)."

It is perhaps always somewhat unfair to abstract a portion of an author's writings from its context and then to criticise it, but the statement made above appears at first sight to imply a want of appreciation of the conditions created by modern artillery and rifle fire. Sir George Clarke in the above extract no doubt refers to the large and conspicuous traverses which have taken such a large part in the composition of the parapets and ramparts of our permanent works in the past. Such traverses, except for the protection of gun emplacements, are no doubt practically useless; but modern fire conditions seem to necessitate the erection of small traverses and parados in much greater numbers and to a much greater extent than (except in one instance) has been the practice hitherto.

This idea is in no way original, as Colonel J. F. Lewis, R.E., in *Fortification for English Engineers*, published by the R.E. Institute in 1890, in criticising the design of the above-mentioned redoubt, says on p. 34 :—"The weak part of the design is the absence of any protection for the men at the parapet against high angle fire from howitzers or rifled mortars. Light traverses, which would check the dispersion of fragments from shells filled with high explosives, could be easily added." It is thus evident that the question of traverses or no traverses is a vexed one. But before going into the reasons why light traverses are absolutely necessary, it may be stated that in 1890 the effects of high explosive shells against earthworks appear to have been much overrated. The experience of the Boer War seems to point to the fact that men behind properly constructed earthworks are as safe from the effects of high explosives as human methods can make them; and that to obtain their full effects high explosives require to be discharged from a high velocity gun and to have a hard unyielding and upstanding target. Now properly constructed earthworks will never fulfil these latter conditions.

What then, mainly, are the weapons of which the effects must be

feared by a rifleman? The shrapnel and rifle bullet. In what way will these missiles approach him, and where can we find a parallel in the past to these modern conditions? Take any part of a modern defensive position when under fire, whether part of a temporary or of a permanent line. How is it attacked? Mainly by shrapnel and rifle fire, the rifle bullets from any range up to 2,000 yards, and possibly even over that, and shrapnel from any range up to 6,000 yards and perhaps over. Now these ranges admit of a wide choice of position and fire on the part of the attacker. He can fire from almost every direction, and, whether unconsciously or by design, may be at the same moment firing directly at one portion of the defensive line as well as enfilading another, even taking it practically in reverse, and this from almost every conceivable range within the limits stated; so that his bullets arrive at the defensive position at almost every conceivable angle of direction and drop.

Now where in the past could men be found in such evil case as riflemen in the defence to-day? There is only one example that comes to mind: the Sapper excavating the approach towards the salient of the covered way between the third parallel and the "crowning." He too was exposed to fire from the front, from the flanks, and possibly from the rear? How did he protect himself? By excavating a cube or rectangular sap. What was the essential nature of this form of sap? It was a trench provided with traverses and parados. This gives us a guide as to the form our trenches and parapets should take to-day.

The accompanying sketches indicate a form which the alterations to modern defensive works might take. In *Fig.* 1 the parapet with traverses and parados has been freely applied to the five front faces of the redoubt in *Plate* VII. of *Fortification for English Engineers*, and also to a certain extent to the flanks. In *Fig.* 3 the same method has been applied to a modified extent to the front faces of *Plate* IV. of the same book. The guiding principles adopted in the sketch proposals are :—

1. That there should be a minimum length of 30 ft. parapet between traverses, and that, if possible, the maximum length should not be more than 60 ft., thus giving five to ten rifles to a section of parapet.

2. That the trench, in which the men lining the parapet sit during a heavy bombardment or rifle fire, should not be more than 2 ft. 6 inches wide at the top, thus ensuring that men sitting down would practically be safe against shrapnel fire.

3. That the parapet should be 2 ft. 6 inches thick as a minimum at the sill of the loopholes, and that the tops of the traverses and parados should have a minimum thickness of 2 ft. 6 inches. This thickness is the minimum that will stop a rifle bullet at short range; it is sufficiently thick to stop a shrapnel bullet, and would also stop a good many shell splinters.

The objections that can be urged against this form of parapet can probably be foreseen. They are :—

1. That communication in such narrow trenches is difficult.

2. That fire control will be impossible with a parapet so cut up by traverses.

3. That both traverses and parados are too flimsy.

4. That machine guns cannot be worked from this form of parapet.

5. That sunk parapets would be difficult to construct and maintain in peace time without concrete revetments, and that concrete revetments are objectionable on account of the rebound from them of bullets and splinters.

6. That there is no overhead cover.

These objections are met to a certain extent by the following :—

1. The provision of numerous flights of steps or ramps from the main road of the fort or redoubt into the trench forming the rifle parapet.

2. The parapet is divided into convenient lengths for control by one non-commissioned officer.

3. The minimum thickness to resist modern rifle fire is given ; more need not be attempted, as a heavy shell will deform any description of parapet. Thicker traverses would take up too much room in the parapet, and thicker parados too much depth, thereby increasing the target supplied by the fort to the enemy's guns. However, there is no reason why the exact form of traversing shown should be adopted : *e.g.* on the faces of the redoubt in *Fig.* 1 the position of the parapet between two traverses might run on the alignment formed by the two rear ends of the traverses, the parapet being loopholed in the usual manner ; this does not apply to the portion of parapet at the salients.

4. The parapet at the sill of the loopholes is so thin that a few strokes of a shovel would quickly clear away sufficient space to work a machine gun on a tripod mounting.

5. This is perhaps the most serious objection of all. Concrete revetments for the trench must not be used. Probably the best solution would be a suitable corrugated-iron and timber revetment, which might be kept in store in peace time and put in place on a declaration of war or when relations became strained. If not kept in store the cost of maintenance would probably be considerable. There is not the same objection to corrugated iron as there is to concrete ; a bullet or shrapnel ball will not glance off corrugated iron, but will as a rule penetrate and lodge in the earth behind it, and in this case the corrugated iron is backed by earth.

6. In this form of narrow trench overhead cover can easily be improvised.

If corrugated iron and timber is kept in store for the revetments it would be just as well to increase the storage accommodation and

keep loopholes in store as well. A suitable pattern of sheet-iron box loophole would save much time if the parapet had to be quickly prepared for use, and would not seriously deteriorate in store as sandbags frequently do.

The siege of Port Arthur seems to point to the fact that electric light projectors are an indispensable part of the furniture of a modern fortress. Two to each fort or permanent redoubt would seem to be necessary. It does not seem advisable to provide permanent emplacements for these; for it is conceivable that they might both be required on the same side of the fort or redoubt, and the leads can be taken anywhere. The engines to work the projectors might be accommodated in the central casemates. When a siege has progressed somewhat a suitable place for a projector could easily be obtained by modifying a gun emplacement, it being presumed that during the middle period of a siege the guns would be removed from the forts to batteries outside.

This latter point brings us to the very vexed question as to whether guns should be placed in forts at all, and if so, what guns. On the whole it seems best to place a few powerful guns in the forts, on travelling or movable carriages so that they can be placed in the intervals after the main attack of the besieger has developed. The reason for this is that permanent fortification must be considered from a political as well as a military point of view. If no gun emplacements were provided in the forts it is conceivable that a Government in a fit of economy might omit to provide the fortress with any guns at all; whereas if emplacements were provided in the forts, and it came to be known that they were unarmed, the newspapers would probably make such an outcry that the Government would be compelled to provide sufficient armament for those emplacements at least, and thereby a certain number of guns for the fortress. From this point of view four guns per fort would not seem an overwhelming armament.

Probably the heaviest gun that can be easily obtained in any number is the 4·7″ Q.F. The Admiralty are practically abolishing this gun in the Navy; so that a large number of this class should be easily obtainable; after providing for the requirements of our coast-batteries probably a sufficient number would be left over for our important land fortresses. The trend that Naval construction is now taking seems to point to the probability of a large number of 6″ Q.F. guns being available for land works at no very distant date. If this prove to be the case, it might be advisable to mount these in our detached forts on fairly mobile carriages. There is, however, one advantage in employing the 4·7″ Q.F. gun; and this is that we have already in the Army several heavy field batteries armed with this pattern of gun, so that there must now be a considerable number of men trained to its use; as a

rule, for guns of the same date, the heavier the gun the more complicated its mechanism.

Having considered the nature of the guns to be mounted it is necessary to refer for a moment to the method of mounting them. Let us presume, for the purposes of this article, that they are on some form of travelling carriage and have to be moved about; and that the conditions of efficient service do not allow of their being mounted on an overbank carriage, but that, being Q.F. guns, the carriages have little or no recoil. If the above presumptions are correct it would probably be possible to place the gun and carriage on some kind of concrete drum, with the numbers working the gun standing at a lower level, so that only the gun layer is exposed. If the emplacements shown in *Fig.* 3 are not large enough to admit of this they could probably be easily modified to the necessary extent.

Now comes the question as to whether it is advisable to mount the guns on the front faces of the fort at all. On looking at the front faces of *Fig.* 3 it becomes evident that the gun emplacements with their traverses and ramps take up a huge proportion of the interior of the fort and of the length of parapet. It is conceivable that it might be better to mount the guns on the central and rear casemates and to make the main parapet similar to that in *Fig.* 1. If this were done some other means than ramps must be provided for moving the guns. Colonel Lewis anticipates this proposal on p. 101 of *Fortification for English Engineers,* where he says:—"The easiest way to attain it sometimes is to have an opening in the floor of a bombproof and to hoist the guns up vertically." The simplest solution of the problem would be to provide hydraulic or electric lifts, similar to those used in large railway stations for moving luggage from a platform on a low level to one on a higher. On these lifts the gun and carriage, together or separately, could be lowered to the casemates beneath and to the general level of the main communications of the fort. The present writer has hesitated to indicate on the sketches such a method as this, as he does not possess sufficient data to work out the form and size of the lift or even to make certain whether such a method would be practicable. The weight to be moved, however, does not seem to be so very excessive, about 4 tons in the case of the 4·7″ Q.F.; and the space required for the lift in plan would seem to be about 16′ × 6′, say 100 sq. ft., which is considerably less than that occupied by a ramp.

If lifts are ever adopted the power for working them must be considered. If projectors are provided for the forts there would be little difficulty about this; the dynamos being connected up with the necessary motors when required for the lifts, a switch at each lift, and the necessary leads would seem to be all the accessories required; while accumulators might be added to work a system of incandescent lighting throughout the fort. If the gun emplacements were placed

on the front faces it is conceivable that they might be used as a rapid method of getting riflemen on to the front parapet in case of a sudden dash on the part of the besiegers; in place of the road in rear of the front parapet a casemated passage might be employed, which would greatly add to the security of the defenders.

Leaving the question of lifts and armament let us again return to more actual facts. One advantage of the form of parapet proposed has not yet been brought out, that is its use during the closer stages of a siege. The Royal Military Academy *Text Book of Fortification*, Vol. I., published about 1880, says:—"Use should be made of counter-approaches. They are made towards the front to furnish a close fire upon the heads of the approaches . . . or pushed out to a flank to enfilade the approaches or take them in reverse." (*Vide* Clamart Station, Siege of Paris, 1870. Viollet Le Duc's *Annals of a Fortress; The Last Siege.*)

As regards secondary armament the writer submits to Colonel Lewis's opinion that tourelles are necessary. The only amendment he would like to make is that 12-prs. should be employed; this would give a gun which, though certainly more expensive, has a muzzle energy of 423 foot-tons as against the 137 foot-tons of the 6-pr.

On looking at *Fig.* 1 it becomes easy to imagine that it might readily occur to the commander of a similar redoubt to break out from the parallel formed by the front parapet, and to make counter-approaches against the besieger wherever necessary over the superior slope of the front parapet; as long as the sunken railing was intact he would know that his sappers could work in perfect security against any rushes from the enemy and that his counter-approaches could not be rushed and seized. There is one objection to this method; it is clearly stated by Sir George Clarke in his above-mentioned book:—"To work on a slope turned towards the enemy is a hazardous operation even by night, while the cessation of the artillery fire of the upper rampart would be further entailed." Sir George Clarke refers to one of General Brialmont's forts after the parapet has been deformed by heavy artillery fire, so that the case is not exactly parallel; but this objection has such weight that it is necessary to consider how it can be met. There are two answers to the objection just as there are two parts to the above quotation. The first is that the superior slope must be very flat, about $\frac{1}{15}$ as a maximum, when the objection ceases to have very serious weight; secondly, if the guns have been removed from the forts, there can be no interference with the artillery fire of the upper rampart. While considering for a moment this question of counter-approaches, for which it is urged every provision should be made in a modern fortress, it becomes evident that the usual recommendation*—"the glacis should be

* Sir George S. Clarke's *Fortification*, etc.

planted with trees, whose roots when the trees are felled would prevent Sapping"—can only be accepted with the reservation that trees should not be planted closer to the crest of the glacis than 100 to 150 yards; otherwise possible counter-approaches would be interfered with. Counter-approaches, however, seem only possible when the slope of glacis is very flat, so that each case must be considered on its own merits.

These considerations have now led up to a point where it may be asked:—What would an ideal modern detached fort be like? If our premises are correct, our conclusions and their requirements would appear to be somewhat as follows (*Figs.* 6 and 7):—

1. A ring of obstacles with a covered way in front of it; whether the obstacle should be a deep ditch well flanked or a covered railing would seem to be a matter of opinion or expense. Port Arthur seems to point to a deep ditch being necessary in order to force the besieger to mine; this, however, seems unnecessary in England, though it might be advisable in the Colonies.

2. Presuming that a covered railing is adopted, the second requirement becomes a steepish exterior slope, rising at $\frac{1}{3}$ from the covered railing to about the level of the top of the railing, and forming a position defending the ditch.

3. A rounded mound of suitable earth, rising in flat slopes of not more than $\frac{1}{15}$ from the ditch parapet, forming a position for riflemen for the close defence of the position. In this mound suitable trenches might be dug previous to the siege along the line of the probable front faces required, and positions might be prepared for field guns; or the preparation of the necessary trenches might be postponed until the declaration of war. But in the mound must be provided sufficient casemates for storage and for the garrison in time of war. Behind the mound must run a sunken roadway for communications or a suitable casemated passage with communications to the trenches.

4. Behind the mound again, or included in it, must be emplacements for guns of position, with means (lifts or ramps) of removing them to outside the fort.

5. Dynamo and accumulator room to provide the necessary power for working the projectors, incandescent lights, and lifts.

The writer has neither the data nor the time available to draw the plan of such an ideal fort. Moreover there are many objections to the proposal contained in the above five headings. Three seem almost insuperable, viz.:—

1. The resulting plan would be so deep from front to rear that the fort would cover an enormous area and would therefore present a very deep target to the enemy.

2. The ring of obstacle required to enclose such a work would be very long and therefore very costly.

3. The form of design proposed would only be suitable to very flat

sites or at any rate to gently undulating country. It would be impossible, for instance, to occupy a steep narrow ridge in this fashion. *Fig.* 7, however, gives some general indication of the form that the work might take.

Nothing up to the present has been said in this article regarding coast fortification. There is one conclusion, however, to be drawn from the attempts of the Japanese to "bottle up" Port Arthur, namely :—that a power having command of the sea would be willing to sacrifice ships of no great value in order to enable torpedo craft to attack ships lying in a harbour with a narrow mouth protected by a boom. The ship or ships employed on such a service would probably be old merchant ships of sufficient size to smash boom defences even when travelling at slow rates of speed. The very size of such ships would be a protection to them against the fire of the smaller fortress guns, and it becomes necessary to consider whether each boom defence should not have a battery or batteries of two or more 6-inch guns sited to seaward of the boom and firing over the "lighted area." The 6-inch is the smallest gun that can be depended on for such work and its rate of fire is such that it should be able to accomplish its object in the short time available.

The objection to the above proposal is that the guns, by sinking the attacking vessel, might merely be accomplishing a secondary object of the enemy, namely :—To block the harbour mouth. The answer to the objection is that no attempt to "bottle up" a harbour has succeeded as yet, and with powerful dredgers available an alternative channel might be quickly dredged, or the obstruction removed by explosives.

To those acquainted with our coast defences, several instances will occur where the 6-inch boom batteries advocated might be adopted with advantage.

In conclusion the writer would beg to state that, if any of the ideas here put forward have previously appeared elsewhere than as noted in the text, he is not aware of it and apologises for his unconscious plagiarism. He also desires to thank the R.E. Institute for permission to make use of the plans published in Colonel Lewis's book.

THE ENGINEERS OF THE GERMAN ARMY.

By Col. J. A. Ferrier, D.S.O., R.E.

The technical duties of the German Army are carried out by :—

I. The Chief of the Corps of Engineers and Pioneers and Inspector-General of Fortresses, who has under him

A. (i.). The Corps of Engineers, composed of officers only ; and their subordinate establishment
(ii.). The Corps of Fortress Constructors.
B. The Corps of Pioneers.

II. The Inspector of Communication Troops, who has under him

A. Railway Troops.
B. Telegraph Troops.
C. Balloon Troops.

III. Other cognate duties which we are accustomed to view as Engineer services are carried out as follows :—

A. Barracks and Military buildings, not included under the designation "Fortifications," by the Garrison Bauwesen (Barrack Construction Department), a branch of the Intendantur.
B. Search Lights—By the Corps of Fortress Constructors.
C. Survey—By the General Staff.
D. Submarine Mining—By the Navy.

I. A. (i.). THE CORPS OF ENGINEERS.

The Corps under headings A (i.), A (ii.), and B are distinct as regards duties, although under one Chief.

Duties. The duties of the Corps of Engineers are :—Construction and care of fortifications, fortress telegraph systems, electric lights, pigeon post, and other fortress services ; custody of the demolition chambers in bridges and tunnels.

Officers. The officers are allotted to the various fortresses and are expected to be acquainted with every detail of the defences and the surrounding country.

Members for Technical Committees and Instructional Establishments are also drawn from the Corps.

There are 4 Prussian* and 1 Bavarian Engineer Inspections, controlled by Major-Generals assisted by 2 Adjutants. The Prussian are further divided into 9 Fortress Inspections, controlled by Colonels or Lieut.-Colonels assisted by 1 Adjutant. Engineer Inspections.

In war the officers would be employed in sieges and in defence of fortresses (see later on). War Employment.

ESTABLISHMENT OF OFFICERS.

The Army Estimates for 1905 provide for the following:—

Prussia.

1 Chief of Engineers.
4 Engineer Inspectors.
3 Pioneer Inspectors.
1 President Engineer Committee.
9 Fortress Inspectors.
3 Regimental Commanders and Staff (or Field) Officers in like rank.
3 Chiefs of Divisions in Engineer Committee.
1 Chief Staff Officer of the General Inspection of Engineers, Pioneer Corps, and Fortresses.
67 Field Officers.
88 Captains 1st Class.
63 Captains 2nd Class.
145 Senior Lieutenants.
239 Lieutenants.
40 Junior Lieutenants.

Total 667

Saxony.

1 Commander of Pioneers.
3 Staff (or Field) Officers.
6 Captains 1st Class.
5 Captains 2nd Class.
8 Senior Lieutenants.
21 Lieutenants.
6 Junior Lieutenants.

Total 50

* NOTE.—Including Saxony and Würtemberg, except where otherwise stated.

Würtemberg.

1	Staff (or Field) Officer.
3	Captains 1st Class.
2	Captains 2nd Class.
4	Senior Lieutenants.
12	Lieutenants.
2	Junior Lieutenants.
Total 24	

Bavaria.

The Estimates are not available, but the Army List of 1905 shews under "Inspection of Engineer Corps and Fortifications; Münich,"

1	Chief of Engineer Corps and Inspector of Fortifications.
2	Adjutants.
	and under "Chiefs of Districts (Abteilungs Chefs),"
3	Colonels.
1	Captain.
1	Senior Lieutenant.
1	Lieutenant.
Total 9	(and 1 Head Foreman of Works at H.Q.).

The following para. is then inserted:—"Under the Inspector of Engineer Corps and Fortifications come:—The Pioneer Battalions, Railway Battalion, Telegraph Companies with Cavalry Telegraph School, and the Balloon Detachment, in their personal and technical aspects; the Fortresses."

The 3 Pioneer Battalions have the following officers:—

	No. 1. (Ingoldstadt).	No. 2. (Speyer).	No. 3. (Münich).	Totals.
Staff or Field Officer (C.O.) ...	1	1	1	3
Captains	5	4	3	12
Senior Lieutenants	3	3	1	7
Lieutenants	13	13	7	33
Totals ...	22	21	12	55

From the above we have in the whole Army, in peace time, as officers of Corps of Engineers and Pioneers

Prussia	667
Saxony	50
Würtemberg	24
Bavaria	64
Total	805

It is convenient to treat the officers of the Engineer and Pioneer Corps together as they are so shewn in the estimates. They appear to belong to one list for promotion, and to be interchangeable in the sense that an officer of Pioneers may be transferred to an Engineer Inspection and *vice versâ*. They enter the service under the same system and their preliminary training is identical. It is in their employment only that they differ; for Pioneers have no share in purely Engineer services, in spite of the fact that, in the regulations for the attack of fortresses, the Commanding Engineer and Commanding Pioneer Generals appear to be interchangeable.

The number of officers serving at any moment with the Pioneers is very difficult to determine with any accuracy. They vary enormously from year to year, and so it is almost impossible to arrive at the exact number of officers employed on purely Engineer Corps duties.

Taking the figures for 1904, we find

Prussia and Würtemberg.

514 Pioneers.
202 Engineers.

Saxony.

46 Pioneers.
7 Communication Troops.
3 Staff and Expeditions.

Bavaria.

59 Pioneers.
22 Communication Troops.
36 Engineers.

For 1905 the numbers for Prussia, Würtemberg, and Saxony are approximately the same; those for Bavaria are considerably reduced, as there are only 64 officers altogether, of whom 55 are serving with Pioneers.

OFFICERS' COMMISSIONS.

The Officers enter the Army in the same way as all other officers; they need not necessarily begin their service as Engineer Officers, but can come from some other unit if they pass the necessary examination in going through the new Technical War Academy.

Avantageurs. The usual way is through the ranks. A Candidate, having obtained a 2nd Class Certificate at school, joins a regiment, with permission of the Colonel, as a One-year Volunteer, and is generally known as an Avantageur. For 6 weeks he has to live in the barrack room; after this he is allowed to live out, to mess with the officers, and to wear clothes of superior cloth at his own expense and an officer's great-coat when not on duty. After 5 months' service he passes an examination in military duties, and is nominated Fähnrich. In this grade he serves at least 6 months, thus doing 11 months in the ranks. He then goes to a War School, a kind of Garrison Class, to prepare for the Officers' Examination. Finally he is "chosen," *i.e.*, elected as a brother officer by the regiment in which he wishes to serve; and, after passing the Officers' Examination, is appointed 2nd Lieutenant.

Cadets. Candidates from the Cadet Schools (where, by the way, military subjects are not taught) usually join a regiment from the 2nd Class; and are treated exactly like the One-year Volunteers, except that they join as Brevet Fähnrich and are exempt from the 6 weeks in the barrack room. A small number of Cadets, who remain an extra year at the Chief Cadet Establishment, are appointed direct without passing through the ranks, and go straight to the War School. Selected very brilliant Cadets are promoted from the 2nd Class to the Selected Class, and after one year in it join as 2nd Lieutenants. Candidates who have been one year at an University are allowed to join as Avantageurs, and to pass the Officers' Examination at the end of 6 months' service in the ranks.

Artillery and Engineer School. Engineer and Pioneer Officers are nominated Supernumerary Second Lieutenants and serve as such for $1\frac{3}{4}$ years, at the end of which time they proceed to the Artillery and Engineer School for $20\frac{1}{2}$ months. In the first year they do 2 days' fortification exercises, in the second year 2 days' practical fortification on the ground; the rest of the fortification work is theoretical. On passing the final examination the students rejoin as Second Lieutenants.

It is believed, though no details are to hand, that the experiment is being tried of training young officers for the Engineer Corps, and possibly also Pioneers, at Berlin University (Hoch Schule) instead of at the Artillery and Engineer School.

Technical War Academy. As already mentioned, officers of other arms can pass through the Technical War Academy and become Engineer Officers.

It appears from an article in the *Kriegstechnische Zeitschrift*, reviewed in *R.E. Journal* of April, 1905, that the course is specially

designed to enable officers of the Verkehrstruppen (Communication Troops to be hereafter described), of the Technical Staffs and Establishments (*e.g.* gun, rifle, and ammunition factories), and others who wish to prepare themselves for employment in the Engineer Corps, to obtain such instruction of a scientific and technical nature as is required for military purposes. The subjects of the very comprehensive course are enumerated in the above-mentioned review. They appear to embrace those in our courses at the Royal Military Academy, School of Military Engineering, Artillery College, Staff College, and Schools of Ballooning and Signalling. But Civil Engineering, as such, and building construction and estimating, except as applied to fortresses, appear to be excluded.

There is no equipment particular to the Engineers beyond what is in use in the fortresses. Equipment.

All officers are mounted. Mounted Officers.

TRAINING OF OFFICERS.

This will be dealt with under "Organization of Pioneers." It will be observed that it has been necessary to treat of the Pioneer Officers in describing the Engineers, for both receive their preliminary training in the same way and it seems difficult to divorce them. Beyond the training obtained in the Pioneer Regiment or other unit, the War School, Technical Academy, Artillery and Engineer School, or University, there does not appear to be any special annual training for Engineer Officers; nor is it certain that they take part in the Annual Pioneer Training or Annual Manœuvres as such. But, as will be seen later, Pioneer Officers are annually occupied in training their men with very meagre assistance from N.C.O.'s (who, according to our ideas, serve a very short period), and so are constantly perfecting their knowledge up to a certain point, but mostly in details.

EMPLOYMENT OF OFFICERS (ENGINEERS ONLY).

On the Fortifications; as Instructors at various Military Educational Establishments; on experimental commissions. Peace.

The Handbook (*Taschenbuch für den Pionieroffizier, 1904*) says, in Section VIII., "Fortress Warfare":— War.

Attack.—Attached to the Staff—General of Engineers or Pioneer Corps, for assistance in all questions regarding fortification and the close attack. Draws up projects for distribution and employment of the Pioneers and Pioneer Siege Troops; has special care to the tactical cohesion of the siege works of the Infantry and Pioneers; keeps the Commander-in-Chief constantly *au courant* regarding the condition and resisting capabilities of the works and defensive localities of the Fortress; can demand direct from the Commanding Officers of Pioneers, in the various sections of the attack, reports on the progress

of the works, materials in the parks, the position of affairs, and information in general; and arranges supplementary supplies of siege material for the Pioneers.

* * * * *

Defence.—The Commanding Engineer assists the Governor in all fortification and technical matters; is responsible to him that the Fortress is brought to the highest development of defensive power, and maintained in that condition, and that the whole technical resources of the fortress are utilized in the best possible way; keeps intimate touch with Commanders of Sections of the defence, and can demand direct assistance from the Engineer Officers of Sections; proposes to the Governor the allotment of Engineer Officers and technical troops to the Sections; arranges the assignment and distribution of the working parties, civil labour, field park, etc.; directs the fortification works, including extensions of the interior communications and high roads, until such time as the Section Commanders assume responsibility for the same within their sections; exclusively controls, from the moment they are enrolled, the progress of the fortification civil workmen; arranges any necessary departures from the scheme of the defence works, and authorizes any necessary modification of the scale of labour; arranges the network of armament tram lines, works out the traffic management with the Commanding Officer of Artillery, controls the traffic, and has authority to allot, if necessary, certain sections for particular purposes (connections of service lines to batteries, etc., and their working is the business of the Garrison Artillery); erects, maintains, and works the Fortress telegraph system.

I. A. (ii.). THE CORPS OF FORTRESS CONSTRUCTORS.

The duties of this Corps are confined to the construction of Permanent Fortifications. Although subject to the Inspections of the Corps of Engineers, the *personnel* come under the jurisdiction of the Invaliden.

ESTABLISHMENT.

The Army Estimates for 1905 provide for the following:—

Prussia.

83 Senior Lieutenants and Lieutenants.
6 Pensioned Staff Officers at large Fortresses.
111 Fortress Head Foremen of Works.
1 Telegraph Foreman.
48 Fortress Warders.
206 ditto.
21 ditto as Master Collar Makers with Pioneers.

Saxony.

1 Fortress Head Foreman of Works.
1 Fortress Warder.
2 ditto for Pioneer Battalions.

Würtemberg.

1 Fortress Warder as Master Collar Maker with Pioneers.

Bavaria.

7 Captains.
7 Senior Lieutenants.
2 Lieutenants.
6 Head Foremen of Works (1 at H.Q.).
7 Foremen of Works.

The Corps was constituted by Cabinet order, dated 20th March, 1903. It consists of:—

(i.). Festungs Bau Officieren (Fortress Corps Officers).
(ii.). „ Beamten (F.C. Officials).
(iii.). Wallmeistern (Foremen of Works).

(i.). Are divided into ranks as follows:—

Festungs Bau Hauptleute (Captains).
„ Oberleutnante (Lieutenants).
„ Leutnante (Junior Lieutenants).

They belong to the unattached Active list of Officers of the Peace Establishment.

(ii.). Are divided into:—

Festungs Bau Oberbauwarten (Fortress Head Warders).
Festungs Bauwarten (Fortress Warders).

They belong to the Servisberechtigten Militär Beamten (Covenanted (?) Military Officials), and rank as Officers.

(iii.). The Wallmeister belong to the ranks, with rank of Feldwebel (say, Sergeant-Major).

The Festungs Bau *personnel* are allotted to:—Fortifications; Fort Inspections; Engineer Committee; General Inspection of Engineer and Pioneer Corps; School of Fortress Construction.

The Kingdom of Bavaria has a special F.B. *personnel*; while the officials known as Anwärter (overseers) from Würtemberg and Saxony are taken over by Prussia on nomination to Wallmeister.

RECRUITING AND TRAINING.

The *personnel* is drawn from qualified N.C.O.'s of the Pioneers, who, before appointment as Wallmeister, must undergo a special course of education.

Winter classes are held in Pioneer Battalions to thoroughly educate young N.C.O.'s in all branches of Pioneer work, theoretical and practical, to revive and keep up their knowledge, and to prepare them for the future position of Officials (Beamte). Diligent N.C.O.'s are encouraged by the promise of official posts in civil life. These classes are the basis on which N.C.O.'s work to qualify for admission to the Festungsbauschule (Fortress Construction School). The subjects treated are:—Duties; practical pioneering; the art of fortifying; German language; military correspondence; writing; cyphering; geometry; geometrical and plan drawing; history; geography; and in some battalions stenography.

Festungsbauschule.

The Festungsbauschule is an independent establishment of the Engineer and Pioneer Corps; its object is to prepare candidates by yearly examination for Fortress Corps Officers.

It is in the Charlottenberg Garrison, and its Director is a Field Officer of the Engineer Corps. It is under the President of the Engineer Committee, under the control of the Inspector-General of Engineers and Pioneer Corps, who chooses the syllabus and orders books and instructional material. Its administration is subordinate to the Prussian War Ministry.

Nominees are N.C.O.'s of unexceptionable character of from 5 to 6 years' service in the army with a minimum of 3 years as N.C.O. Exceptions are made for one-year volunteers who have passed through Technical Schools. The Course lasts 1 year 9½ months, and includes free gymnastics and use of weapons; 27 days' leave per annum are allowed. Examinations are held every quarter, and there are two yearly entrance examinations, written and *viva voce*. Failure means return to the unit for 1 year, after which a second and last chance is given.

EMPLOYMENT.

Peace.—On Fortification work, generally. At Headquarters with the Engineer Committee, Technical School, or like Establishments, or in the Verwaltungs Schirrhof (a large central store or park in which books and ledgers are kept by the nominees).

Independent Forts are the most popular service. The duties comprise electrical works, fortress telegraphs, and pigeon post.*

War.—The Corps generally remain in their fortresses, except some officers and foremen of works who take the field with Siege Corps and work search lights. The *personnel* on declaration of war is at the disposal of the I.G. of Engineer and Pioneer Corps, and can be ordered abroad.

* But the Pigeon Post Wallmeister are not required to pass through the Fortress Construction School.

I. B. THE CORPS OF PIONEERS.

ORGANIZATION.

There are 26 *Pioneer Battalions in the 4 Prussian and 1 Bavarian Engineer Inspections (Technical) under the Inspector-General of Engineers and Pioneers, who is assisted by 4 Engineer and 3 Pioneer Inspectors as his agents. The battalions each have 4 companies in peace; they are distributed in Table I.

Second Line Troops.

A Reserve Pioneer Field Company, with Reserve Divisional Bridge Train attached, will be provided for each Reserve Division. The number of Reserve Divisions would probably be 2 in each Army Corps District of 2-Division Corps and 3 in the Districts of 3-Division Corps (viz., I. and XIV.).

The Depôt Companies will probably number 26, one per battalion; but it is not absolutely certain that more than 20 are at present organized. Each is formed from 50 Ersatz† Reservists, Active Reservists, and Landwehr men as required.

The Landwehr Pioneers will form 60 Fortress Pioneer Companies.

The total available Pioneer Troops may be put in round numbers at 1,180 officers and 54,000 rank and file.

Each Army Corps has one Pioneer Battalion, except the I., XV., and XVI. Corps, which have two.

War Formation.

On mobilization each Pioneer Battalion forms:—

(*a*). A Battalion Staff, which joins the staff of the G.O.C. Army Corps.

(*b*). Three Pioneer Companies, one being permanently attached to each Division, and the third kept at the disposal of the A.C. Commander.

(*c*). Two Divisional Bridge Trains, one attached to each Divisional Pioneer Company.

(*d*). One Corps Bridge Train, with a special detachment of Pioneers.

(*e*). Two Siege Companies.

The details of units are shown in Tables II. and III.

The 1st and 14th Battalions will probably each mobilize 4 Pioneer Companies and 3 Divisional Bridge Trains, as the Army Corps to which they belong have each 3 Divisions. Certain other battalions, probably 11, will mobilize detachments of Pioneers to accompany the Cavalry Divisions. On the other hand the 18th, 19th and 20th Battalions would probably be employed as Fortress Pioneers in their respective

* Viz. 20 Prussian, 2 Saxon, 1 Würtemburg, and 3 Bavarian.

† Composed of supernumeraries not taken for the annual contingent, men excused service for family reasons, minor bodily defects, temporarily unfit likely to recover. The first category has almost died out owing to full annual contingents being absorbed.

fortresses (Table I.), mobilizing 8 Siege Companies each. The total number of field units mobilized would, therefore, be :

23 Staffs.
71 Field Companies.
48 Divisional Bridge Trains.
23 Corps Bridge Trains, with Pioneer detachments.
70 Siege Companies.
11 Pioneer detachments for Cavalry Divisions.

PIONEER COMPANIES.

Arms.

Officers, Medical Officers, Officials, Sergeant-Majors, vice-Sergeant-Majors, and Ensigns are armed with swords and pistols (revolvers or repeaters); buglers with sword bayonets and revolvers; officers' servants and hospital assistants with sword bayonets only; transport (Train) drivers with O.P. cavalry swords only; other ranks with 1888 and 1898 pattern rifles and sword bayonets with saw backs.

Personal* Equipment.

Belts and straps are of black leather. Kits are carried in cowhide knapsacks, supported by braces attached to the waistbelt. Inside the knapsack is a bag for reserve rations, which can be carried separately if knapsacks are left behind. On the waistbelt, on each side of the buckle in front, is a pouch for 45 rounds, and 30 more are carried in the reserve ration bag. A haversack, light-brown, is looped on to the belt on the right side; in rear is the oval aluminium water bottle, covered with grey felt and provided with cup; on the left side are carried the sword bayonet and also the head of an entrenching (or other) tool, in leather pocket, the handle sticking up alongside the knapsack to which it is strapped. Each man also carries a portion of a tent,† consisting of a canvas square with eyeletted edges, a pole in 3 pieces, 3 tent pegs, and a cord; the canvas square is rolled and strapped on to the knapsack, which it envelops on the top and two sides. The mess tin is strapped on the back of the knapsack at top. The whole equipment, put together, can be taken off and on like a coat. The total weight, including arms, carried in F.S.M.O. by a man of medium height is about 59 lbs.

Tools.

The portable tools carried by each company comprise 88 large shovels, 44 pickaxes, 45 axes, and 18 hatchets. Table IV. gives the tools carried in the wagons.

* For uniform, see Appendix.

† Two men can make an inverted V tent; other combinations can be made by larger numbers. The canvas square can be formed into a float to carry a man's equipment, by connecting opposite corners and stuffing the envelope thus made with straw, etc.; several combined can be made into a raft, and so on.

The horses and drivers for the Company Transport are furnished by the Train. Transport.

The four carriages are a 2-horse baggage wagon, a 2-horse provision wagon, a 4-horse tool wagon, and a 4-horse wagon for explosives. There is 1 pack horse.

DIVISIONAL BRIDGE TRAIN (PRUSSIAN).

This Bridge Train is divided into two sections. The first has 1 trestle wagon, 1 pontoon wagon with chock baulks, 2 pontoon wagons with baulks, all 6-horsed; 1 tool wagon and 2 store wagons, 4-horsed. The second section has 1 trestle wagon, 1 pontoon wagon with chock baulks, 2 pontoon wagons with baulks, all 6-horsed; 1 supply wagon and 1 store wagon, 4-horsed. Reserve, 1 baggage cart, 2-horsed. Transport.

The 53 N.C.Os. and men and 87 horses are provided by the Train.

One of the 2 Lieutenants is with the Reserve.

In addition to the above Train *personnel* are, of course, the Pioneer detachment detailed in Table III.

The length of bridge carried is 120 feet, of normal (*i.e.*, 9 ft.) width. The contents of wagons are given in Table IV. For further details as to pontooning see below, page 46.

March orders prescribe the position of the Divisional Bridge Train. If its use is expected it is attached to the Advance Guard Pioneer Company, otherwise it is told off to march with the Heavy Baggage or even with the Train. Certain wagons, as required according to circumstances, can remain with the Pioneer Company. The order of wagons on the march depends on their prospective use.

The C.O. of the Company to which the Divisional Bridge Train is attached is officer commanding the whole, but when the Train is separate the Senior Train Officer commands it.

The Senior Train Officer deals with all interior details and economy of the Train *personnel*, being responsible for the same to the Company Commander. He has the powers of a Company Commander regarding disciplinary punishment of the Train rank and file; if detached at some distance from the Company he exercises these powers also with regard to the attached Pioneer detachment (Table II.). He employs the Junior Train Officer as his subaltern. He is responsible for the training, etc., of the Train rank and file, and for the condition of horses, clothing, equipment, harness, stable gear (renewals must have concurrence of Pioneer Company Commander); he disburses pay, arranges rations and quartering of Train rank and file, feeding of horses, and representation of complaints, and keeps up the war diary.

Higher disciplinary punishments and first court of appeal are vested in the Officer Commanding Pioneer Battalion with the Army Corps.

In the Reserve Division this function falls to the Divisional Commander. But in all cases the Divisional Commander is the supreme court of appeal.

Equipment. The belts and straps are white for mounted, black for dismounted men, except in the 12th, 13th, 19th, and 25th Battalions, where they are black for all.

Kits for mounted N.C.O.'s and men are carried in two roomy wallets; corn sack and rolled cloak strapped behind the saddle.

Dismounted men in peace carry their own knapsacks; in war they are carried on the wagons; mess tin strapped to rolled great coat, in a fold of which is placed the forage cap. The tent equipment is packed in sacks and carried on the wagons.

Arms. N.C.O.'s, mounted lance-corporals, trumpeters, artificers, workmen, and spare drivers are armed with cavalry carbines (1888) or (in Bavaria) with revolvers, but other ranks have no firearms. All mounted men have an O.P. cavalry sword and dismounted men an O.P. infantry sword bayonet.

CORPS BRIDGE TRAIN (PRUSSIAN).

This is composed of a detachment of Pioneers (2 Officers, 7 N.C.Os., 1 Trumpeter, 53 Pioneers, 1 Hospital Attendant, 2 Batmen, 2 riding horses) and two Half Columns, to the first of which is attached the Reserve.

I. HALF COLUMN.

No. 1 Section.

1 Lieutenant.
27 R. and F.
50 horses.
1 trestle wagon
1 pontoon wagon with chock baulks } 6-horse.
5 pontoon wagons with baulks
1 supply wagon, 4-horse.

No. 2 Section.

26 R. and F.
49 horses.
7 pontoon wagons with baulks, 6-horse.
1 tool wagon, 4-horse.

Reserve.

1 C.O.
1 M.O.
1 Paymaster.
1 V.O.
23 R. and F.
23 horses.
1 demolition (explosives) wagon, 6-horse.
1 baggage wagon, 2-horse.

II. HALF COLUMN.

No. 3 *Section.*

1 Lieutenant.
28 R. and F.
51 horses.
1 trestle wagon
1 pontoon wagon with chock baulks } 6-horse.
5 pontoon wagons with baulks
1 supply wagon, 4-horse.

No. 4 *Section.*

26 R. and F.
49 horses.
7 pontoon wagons with baulks, 6-horse.
1 tool wagon.

The length of bridge carried (26 pontoons, 6 trestles) is 431 feet as a maximum, but normally 397 feet.

The Corps Bridge Train is an independent command. The C.O. has the disciplinary powers of a detached Captain of Train: the senior officer of the Pioneer detachment those of a Company Commander. The Commandant of Train has the disciplinary powers and exercises the court of appeal of an independent battalion commander. The General Commanding is the highest court of appeal.

The G.O.C. determines the situation of the Bridge Train or its headquarters are settled by its employment. When it is in actual use the C.O. of the Bridge Train has to conform to the requirements of the Pioneer Officer in charge of the Bridge Construction, without regard to seniority.

Personal equipment, kits, and armament are the same as for Divisional Bridge Train.

HEAVY RHINE BRIDGE TRAIN.

In addition to the above is this following special unit. The wagons comprise 96 pontoon, 10 trestle, 4 shore bay, 2 anchor, 2 tool, 2 supply, all 4-horse; and 1 baggage wagon, 2-horse. The pontoons (except the anchor boats carried on the shore bay wagons) are half pontoons.

The attendant Pioneer Company consists of 5 officers and 258 R. and F., with 1 field demolition (explosives), 1 baggage, and 1 supply wagons. Length of bridge all in—

48 pontoon bays at 5·75 m. = 276
14 trestle „ at 4·24 m. = 59·36

335·36 m.
or 367 yards nearly.

OTHER *MATÉRIEL.*

Steel Boat Bridge Train for a Cavalry Regiment.—This consists of two 4-horse wagons, each carrying 2 steel boats and 4 bridge superstructures, 4 m. long, 1 m. wide. From this can be made :—1 raft, 16 square mètres; or 1 footway, 1 m. wide, 20 m. long; or 1 light bridge, 2 m. wide, 12 m. long; or 1 column bridge, 3 m. wide, 8 m. long.

The raft can carry in fine weather :—1 gun with limber and gunners complete for war; or 4 horses with attendants; or 1 troop wagon; or 50 saddles, kits, and equipment of 50 cavalrymen; or 30 infantry in heavy marching order; and proportionately less if weather is bad.

Folding-boat Equipment in place of steel boats. Each regiment has one 6-horse wagon, with 4 half-boats and 4 superstructures.

BAVARIAN WAR BRIDGE TRAIN.

Matériel. Pontoons for bridge are made up of a bow piece and a stern piece connected or of 2 bow pieces with 1 stern piece between. Each bay has 7 chock baulks or 7 shore baulks.

Divisional Bridge Train. The number of carriages in the Divisional Bridge Train is the same as in the Prussian unit, enough for 43·5 m. length of bridge (47½ yards). From this *matériel* can be made :—Footway (3 baulks), 85 m.; light bridge (4 baulks), 60 m.; column bridge (normal), 40·34 m.; ditto (strengthened* for heavy carriages), 30·22 m.; heavy column bridge (infantry crowded), 24 to 26 m.

Corps Bridge Train. The Corps Bridge Train wagons are :—24 6-horse for baulks and trestles and 8 4-horse for pontoons. The tool, store, demolition, and baggage wagons are the same as in the Prussian unit, enough for 166·64 length of bridge (182 yards). The following lengths of bridges can be made :—Footway (3 baulks), 270 m.; light bridge (5 baulks), 165 m.; column bridge (normal), 144·38 m.; ditto (strengthened† for heavy carriages), 82·74 m.; heavy column bridge (infantry crowded), 63 to 83 m.

SIEGE COMPANY.

The Siege Companies are organized like a Pioneer Company, less one 2nd Lieutenant and the Bridge Train; and the personal equipment, kit, and armament are exactly the same. Attached to each Siege Company there is a "Pioneer" Siege Train (equivalent to our R.E. Siege Park), of 4 sections and a reserve. Details of the wagons and their contents are given in Table IV.

No details are to hand of the *personnel* furnished by the Train, but it may be set at approximately 2 Officers, 15 N.C.O.'s, 4 Trumpeters, 2 Shoeing-smiths, and 116 Drivers.

* 72 chesses short for complete strengthened bridge to be double chessed.

† 4 chesses short for double chessing.

PIONEER DETACHMENT FOR CAVALRY DIVISION.

This consists of 1 Lieutenant, 30 R. and F. Pioneers, 3 Train, with 2 riding horses for the officer and a 4-horse equipment and store wagon.

The men would probably use bicycles or be carried in requisitioned carriages. During manœuvres 2 ladder-sided 2-horse wagons carried a detachment of strength as above. The personal equipment, armament, etc., are the same as for Field Companies. The portable tools comprise 13 large shovels, 6 pickaxes, 8 axes, and 3 hatchets.

RECRUITING AND PAY.

The Pioneers receive their recruits, about 250 per battalion, in November. As far as possible boatmen, carpenters, navvies, raftsmen, etc., are allotted to them after the usual selections have been made for the Guard and Artillery.

Terms of Service.

Service is for 2 years with the Colours, from 20th year of age; 5 years with Reserve; 11 years, approximately, concluding on 31st March of the man's 39th year, in the Landwehr; and the remainder of his service up to end of 45th year of age in the Landsturm 2nd* Levy.

One-Year Volunteers.—Young men who reach a certain standard of education, and who engage to clothe, feed, and equip themselves, obtain the privilege of being transferred to the Reserve at the end of 1 year's service with the Colours, and are called "One-year Volunteers." It is from this category that Avantageurs (see above, I. A (1), under "Officers' Commissions") and the large majority of the Reserve Officers are obtained.

Two, Three, and Four-Year Volunteers.—Men who have completed their 17th year, and are desirous of making the army their profession or of serving in a particular regiment, are permitted to volunteer for a period of 2, 3, or 4 years, after which they may re-engage.

From this category comes the bulk of the non-commissioned officers. Other N.C.O.'s come from the Under Officers' Schools; these men engage to serve 4 years in the Army.

Pay.

There is no Corps pay (or, as we know it, Engineer pay) for officers and rank and file.

The officers are paid at the same rate as those of the Cavalry, Artillery, and Train. A Pioneer private receives 10s. 6d. a month.

* The 1st Levy, intended for home defence but liable on emergency to be called up to fill the Army, is composed of all males (who do not belong to the army or navy) from 17th birthday to 31st March of year in which they complete 39 years of age.

TRAINING.

An Imperial order lays down that Pioneers, by their training and armament, are as well able as other troops to take their part in actual fighting, although their special duty is the execution of technical works in the presence of the enemy.

The training of the rank and file embraces that of the officers, whose practical work is all assimilated during their period of service in the ranks; their theoretical instruction comes afterwards (see above, I. A (1), under "Training").

From the date of joining, in November, until the end of May the training is that of an infantry soldier. The hours of work are generally 6 to 11 a.m., 2 to 4 p.m., and one hour's theoretical instruction in the evening. In the middle of February the recruits are mixed up with the older soldiers; company and battalion drill are practised, and the musketry course carried out (Pioneers are allowed less ammunition than the infantry); instructional firing is not executed at ranges exceeding 400 mètres. At the end of May the infantry training ceases, except one day's drill a week, and fieldworks are begun. The instructors are the Company Officers.

Field Fortification.

The regulations lay down that each soldier must be practised in all the works of the *Feldbefestigungs Vorschrift* (abbreviated F.B.),* a small book of 84 pages, including plates which are embodied in the text. The instructions it contains are general; for, as usual, much is left to the intelligence and initiative of the officers. A few extracts from the General Observations will suffice to give an idea of the scope.

"(i.). Aim and object of F.F.

"The power of modern firearms has increased the importance of fortifications in the field.

"In season and in the right place they render important, sometimes indispensable, service: while they augment and conserve the fighting power of troops they enable small forces to offer strong resistance or admit of troops being spared to deliver a counterstroke at a decisive point.

"Even on the offensive, localities won can be fortified with advantage.

"(ii.). The C.O. prescribes the use of field defences, so it is necessary they should serve in every case the aims of the leader and not, the other way about, cramp his action. The latter happens when work is begun before the object is determined. Premature fortification of the field of battle is pernicious, for it destroys freedom of movement.

"(iv.). In the close examination of the ground too much importance must not be attributed to isolated imperfections. Weak points in large positions are unavoidable, and must be compensated by stronger dispositions.

* D.V.E. No. 230. Berlin, 1893. Mittler & Sohn, Kochstrasse, 68—70. New edition corrected up to April, 1903.

"(v.). The position chosen must invariably be judged from the attacker's point of view and, when possible, viewed from the front.

"(vi.). Once the decision to fortify is arrived at, it must be determined whether the decisive battle is to be accepted there or only time to be gained.

"(vii.). Strong obstacles in front invite the enemy to a turning movement and hinder the counterstroke. They *can* be valuable when the flanks are secure or when the object is to gain time by forcing the enemy to a turning movement.

"(ix.). The first consideration is a free field of fire—(describing it). A cross fire on the probable lines of approach, and the power of unison between infantry and artillery up to the last moment, are most important."

The contents of the book are much the same as practised in any other army from shelter trenches to deep sap. It is laid down that field redoubts are for infantry only, as a rule not less than a company; the trace to be in conformity with the shape of the ground; parapet lowest possible giving command of fire; all sharp angles to be avoided. The type plan is drawn in curves, and a few bombproof and such like covers and traverses on the flanks are indicated. The only dimension given is "about 150 m." for the firing perimeter, *i.e.*, from one inner flank round by the front to the other inner flank.

Siege work is disposed of in 20 paras., 6 pages. One paragraph of 5 lines explains that in Defence "Similar trench work would be used to counter-attack the besiegers." There are no types for siege trenches. Instead of parallels, a series of infantry positions, not necessarily connected together, are prepared. As a rule they are simply improved and widened standing shelter trenches, but may be executed by sapping near the place. Approaches by zigzag are made if necessary. The use of obstacles in front of the infantry fire positions or parallels is recommended. Blindages, constructed of 3-ft. widths of corrugated iron, are much used.

The general opinion in Germany seems to be that artillery will not be able to destroy fortresses; that counterscarps, flanking defences, and obstacles must be destroyed by mining; and therefore that art has come to the front again.

The Courses are divided into 2 sections:— The Courses.

(1). General, the contents of the F.B. text book, carried out by all Pioneers.

(2). Special, (*a*) Pontooning for the men of the Field Companies, (*b*) Mining for the men of the Siege Companies.

The amount of time devoted to each subject is left to the Battalion C.O. Usually 2 months are given to the General Section and 1 month to the Special before the Manœuvres. Every Pioneer is taught to swim.

Exercises and Manœuvres.—About the end of August there are usually Pioneer exercises on a large scale. A number of Field Companies are collected for bridging operations, and the Siege Companies are employed in conjunction with the Fortress Artillery.

Pontooning.

The text book, *Pontonir-Vorschrift* (abbreviated P.V.), 1902, prescribes fixed words of command for the simplest and ever-recurring practices only; but for everything else merely general indications that must be adapted to circumstances.

Technical pontooning instruction is to be brought to a close by exercises in the most variable circumstances. The training of the "last-joined" in boating and individual details of work must be sufficiently advanced for them to join the Field Company on 1st April and share in the pontooning exercise as helpers and carriers.

Exercises in the familiar surroundings of the training ground are to be supplemented by numerous practices in unknown country with horsed wagons and in combination with other arms. . . . Besides training the senior officers and men these exercises will instil in other arms an understanding of the executive capabilities of the Pioneers.

Superiors, from Company Commanders upwards, are responsible for the training of their subordinates. . . . Those in higher positions of command have to see that all parts of the *P.V.* are gone through in letter and spirit.

The pontoon is built of steel or of wood with steel ribs; it is double stemmed, without sheer; about 7½ m. long, 1½ m. beam, and 1 m. deep; straight sides and round bottom; no keel, but two side bottom strakes and two gunwhale strakes, to which are riveted the hooks for lashing on the baulks. There is no saddle. Near the stern at each end is a stout round thwart, round which a bight of the cable is turned and made fast with a woulding stick. As to weight it can be loaded and unloaded by 16 men. These are all the details available.

The baulks are plain, rectangular in section, cut for strength (in contradistinction to stiffness); 5 to the bay. The chesses are like our own, but with holes bored through the ends (reason unknown). The ribands are of the same shape as the baulks. The rack lashings are 4 on each side to the bay, sticks separate. There are no saddles.

Width of Bays:—*Normal*, or "4-gunwhale bridge," 4½-m. centres; can be increased to 4·8-m. centres for lighter bridge, or reduced to 3·30-m. centres for stiffer bridge. "Three-gunwhale bridge," 6-m. centres with baulks, 5-m. centres with chock baulks.

The trestles of the handbook are almost exactly like our Service Trestle, with transom suspended by a chain but without the clamping screws. Chock baulks are used with these, the bay being 5 mètres.

I have given these few details as they appear to be of general interest in emphasizing the difference of the *matériel*. A complete

translation of the handbook would not enlighten us very much, as very few details are given and almost no dimensions. In fact, everything is simplified as much as possible; the *matériel* is issued to the Pioneer, he works with it and takes it as he finds it.

There are doubtless many other patterns of *matériel*, *e.g.*, the Bavarians have a sort of "Birago" equipment. There are some experimental trestles in Prussia with cross legs and transoms of steel piping and built-up W.I. baulks.

Demolitions and Mining are included in the Pioneer Company (Field and Siege) instruction text book, *Sprengvorschrift* (abbreviated *Spr V.*). This is very complete; and is full of illustrations where to place charges of the various kinds of explosives enumerated, and how to calculate their strength. Demolitions and Mining.

The rectangular case and mining frame like our own appear to be still in use; but trials have been made with a sort of triangular one, with flat sill and sides slightly convex outwards, made of T iron. The push pick is more spade shaped than ours. The miner's pick is more like an adze and there is in addition a broad hoe (not unlike the Indian *phaora*), 15 c.m. × 15 c.m., with 40-c.m. handle.

An illustration may be given of the manner in which siege works are practised. In 1894 a number of Pioneer Siege Companies and Artillery Fortress Companies were collected near Malmédy, where they constructed works and batteries as auxiliary fortress defences. Siege Works.

These defences were attacked in due form, live shell being fired at them. In 1896 similar siege operations were conducted near Jüterbog with the assistance of the Railway Brigade, who built a narrow gauge line, 51 miles long, in 9 days and transported 300,000 tons of siege material.

The Field Companies and Bridge Trains attend the Divisional, Corps, and Kaiser Manœuvres. Manœuvres.

In recent years the Germans have made more use of trench work than formerly. A good deal more would be undertaken were it not for the fear of fatiguing the men and causing excessive damage to crops, trees, etc. The Army Orders on the subject of manœuvres are very comprehensive and enjoin the employment of Pioneers. If the technical work cannot actually be carried out, the Pioneers, who would have to do the work, are to be taken to the spot and kept there for as long as the work would take in reality. Pioneer Officers are required to make all the necessary arrangements, take note of the military situation, and estimate materials, time, etc., reporting to the Officer in Command. Umpires in their decisions will take these works into account.

Great stress is laid on the value to Pioneers of noting the intimate connection that should exist between their work and the action of the troops taking part in the sham fight; and the very short time available for making field works should accentuate in the mind of the

Pioneer Officer the practical utility of highly-trained technical troops. General Officers also, becoming accustomed to the presence of Pioneers, would learn to consider them in their march and disposition orders.

As a matter of fact very little trench work can be done, and most of the work of Pioneers on manœuvres consists in bridging. In fact the general spirit of the text books seems insensibly to lay more stress on bridging than on anything else, and the compiler of this article pleads guilty to have (almost unconsciously) been subjected to this influence himself.

After the manœuvres there is a period of comparative rest until 1st November, when winter work, divided into theoretical and practical, commences.

Winter Work.

Three classes are formed for theoretical instruction :—

(1). *Company :* for all men not recruits and not in classes (2) and (3). Lectures are given by the Sergeant-Major on the general duties of Pioneers, interior economy, etc. 16 hours a week are available.

(2). *Battalion :* for all N.C.O.'s, Gefreiter (lance ranks), re-engaged men, and selected one-year volunteers. Lectures are given by Officers on fortification, attack and defence, drawing, interior economy, military correspondence. 17 hours a week.

(3). *Foremen of Works Class :* for senior N.C.Os. wishing to become Wallmeister, *i.e.*, Assistants to the "Engineer" as distinguished from "Pioneer" Officers.

Practical work comprises :—drill, gymnastics, musketry at least once a week ; knotting and rowing drill preparatory to bridging ; solution of geometrical problems on the ground ; use of mechanical powers ; replacing and repairing broken wheels, poles, etc. ; moving heavy weights, trees, etc. ; topography, including sketches of fortifications ; demolitions of all kinds, including blowing up ice ; encampments and their subsidiary works, water supply, etc.

On 14th February, as before mentioned, the second-year men and recruits are mixed up together, and work proceeds as in the first year ; any portions of the course omitted in the first year are taken first after the preliminary work in the second year.

Summary of Training.

Roughly the training may be summarized thus :—

Infantry drill	$10\frac{1}{2}$	months.
Summer F.W. course	7	,,
Winter	$3\frac{1}{2}$	,,
Manœuvres	2	,,
Leave and intervals	1	,,
Total ...	24	months.

As will be seen from the foregoing, the Pioneers have no leisure during peace for employment on Public Works. The whole of their service with the colours is devoted to their training for war. Employment in Peace.

TRAINING OF OTHER ARMS.

Infantry.—On the 1st June, each Infantry regiment sends a Lieutenant (Rifle battalions biennially) and each battalion two Corporals to the Pioneer battalion of their Army Corps for a course of 4 weeks. The 2nd in Command and a senior Lieutenant conduct the instruction, a certain number of Pioneer corporals and privates being detailed to assist.

There is no "shelter trench exercise." The diggers are extended in position at arm's length; each man then puts his spade into the ground at his feet and marks a line to his right-hand neighbour; this is the front cutting line; the back line is then marked according to directions.

Cavalry.—Every year, in June or July, an Officer or N.C.O. of Pioneers, accompanied by 2 or 3 men, is detached to each regiment of Cavalry for 15 days as instructor.

TEXT BOOKS.

Official Text Books appear to be unobtainable; those I have enumerated are published by private industry with official recognition. For convenience sake the whole art of the Pioneer has been boiled down into a small handbook, $6\frac{1}{4}'' \times 4\frac{3}{8}'' \times \frac{3}{4}''$, called *Pionier-Taschenbuch.* This is divided into 12 sections, as follows:—

1. Extracts from the Field Service Regulations.
2. Mensuration, with tables of cubes, squares, and functions of angles.
3. Mechanical powers and machines.
4. Carpentering.
5. Field Fortification, including siege work, revetments and use of brushwood.
6. Communications in the field.
7. Temporary bridge work.
8. Service of the field miner.
9. Encampments.
10. Field expedients.
11. Pontooning, and folding boats of cavalry.
12. Framing of reports, orders, etc.

The Pioneers have been subjected to a great deal of adverse criticism by writers in various German publications. Reorganization is in the air, but nothing official has transpired up to date (1.4.1905).

(*To be continued*).

TABLE I.—DISTRIBUTION OF PIONEER BATTALIONS.

Army Corps.	Headquarters.	Pioneer Battn.	Station.
Guard	Berlin	Guard.	Berlin.
I.	Königsberg	1	Königsberg.
	(East Prussia)	18	
II.	Stettin (Pomerania)	17	Stettin.
III.	Berlin (Brandenburg)	3	Spandau.
IV.	Magdeburg (Prussian Saxony)	4	Magdeburg.
V.	Posen (Lower Silesia)	5	Glogan.
VI.	Breslau (Silesia).....	6	Neisse.
VII.	Münster (Westphalia)	7	Deutz.
VIII.	Coblenz (Rhineland).....	8	Coblenz.
IX.	Altona (Schleswig Holstein and Mecklenburg).....	9	Harburg.
X.	Hanover	10	Minden.
XI.	Cassel (Thuringia & Nassau)	21	Münden.
XII. ..... 1st Royal Saxon	Dresden	12	Dresden.
XIII. ..... Royal Würtemburg	Stuttgart	13	Ulm.
XIV.	Karlsruhe (Baden).....	14	Kehl.
XV.	Strassburg	15 19	Strassburg.
XVI.	Metz.....	16 20	Metz.
XVII.	Dantzig (West Prussia) ...	2	Thorn.
XVIII.	Frankfort-on-Main (Hesse)	11	Mainz (Mayence).
XIX. ..... 2nd Royal Saxon	Leipzig	22	Riese.
I. Bavarian ...	Münich	3 Bav.	Münich.
II. „ ...	Würzburg	2 Bav.	Speier.
III. „ ...	Nuremberg	1 Bav.	Ingoldstadt.

TABLE II.—ESTABLISHMENTS OF UNITS.

Units.	Strength (round numbers).			Baggage.			Depth in line of march including regulation distance.	
				Small.		Large		
	Individuals.	Horses.	Carriages.	Led horses.	Carriages.	Carriages.	Troops and small baggage.	Large baggage.
							Mètres.	Mètres.
A Pioneer Battalion of 3 Companies	810	60	14	6	6	8	400	90
A Divisional Bridge Train...	60	90	14	—	—	1	300	10
A Corps Bridge Train	200	220	34	—	—	—	800	—
A Pioneer Siege Train	310	160	59	—	—	—	—	—
A Pioneer Detachment, Cavalry Division	40	6	1	1	1	—	50	—
The Heavy Rhine Bridge Train	530	554	120	—	—	—	2200	—

NOTE.—The Battalion Officers are:—C.O., 2nd in Command, and Adjutant.

TABLE III.—DETAILED ESTABLISHMENTS.

Details of Ranks, etc.	Pioneer Company.[1]				Special Pioneer detachment attached to Corps Bridge Train.		Pioneer detachment with Cavalry Division.			Remarks.
	Individuals.		Horses.	Carriages.	Individuals.	Horses.	Individuals.	Horses.	Carriages.	
	Higher Establishment.	Lower Establishment.								
Commander	1	1	2	—	—	—	—	—	—	
Lieutenant (mounted)	2	2	2	—	2	2	1	2	—	
,, (dismounted)	2	2	—	—	—	—	—	—	—	
Medical Officer	1	1	1	—	—	—	—	—	—	
Assist. Paymaster	1	1	—	—	—	—	—	—	—	
Sergt.-Major, vice S.M., and Ensign	3	3	—	—	1*a*	—	—	—	—	
Sergeants and other effective N.C.O.'s	21	17	—	—	6	—	3	—	—	
Lance ranks, Pioneers and Buglers...	225*b*	179*b*	—	—	51*c*	—	27	—	—	
Assist. Armourer	1	1	—	—	—	—	—	—	—	
Hospital Attendant		1	—	—	1	—	—	—	—	
Train Soldiers	10[2]	10[2]	—	—	2[2]	—	3[2]	—	—	
Tool Wagon	—	—	4	1	—	—	—	—	—	
Mining Wagon (explosives)	—	—	4	1	—	—	—	—	—	
Small Tool and Store Wagon	—	—	—	—	—	—	—	4	1	
Baggage Wagon	—	—	2	1	—	—	—	—	—	
Supply ,,	—	—	2	1	—	—	—	—	—	
Bicycles	—	—	—	2	—	—	—	—	—	
Totals	268	218	17	6	66	2	34	6	1	

[1] The company detaches to the attendant Divisional or Reserve Divisional Bridge Train 1 Depôt N.C.O., 1 Lance-Corporal, and 16 Pioneers (including 2 wheelwrights, 2 shoeing-smiths, 2 saddlers, 1 tailor, 1 shoemaker).

a. Sergeant-Major.

b. 3 buglers.

c. 1 bugler.

[2] Drivers and draft and baggage horses are furnished by the Train.

TABLE IV.—List of Tools carried by various Units.

Nature of Work.	Name of Article, etc.	Pioneer Company. Portable.	Pioneer Company. 1 Tool Wagon, Entrenching.	Pioneer Company. 1 Demolition Wagon.	Divl. Bridge Train. 3 Tool Wagons, Entrenching.	Divl. Bridge Train. 1 Tool Wagon.	Corps Bridge Train. 2 Tool Wagons, Entrenching.	Corps Bridge Train. 1 Demolition Wagon.	Corps Bridge Train. 2 Supply Wagons.	Ammunition Column.	Pioneer Det. Cavalry Div. Portable.	Pioneer Det. Cavalry Div. 1 Tool and Store Wagon.	Pioneer Siege Train, 4 Sections and Reserve. I. Sec. 1 Entrenching Tool Wagon.	I. Sec. 1 Demolition Wagon.	I. Sec. 12 Store Wagons.	II. Sec. 1 Entrenching Tool Wagon.	II. Sec. 1 Demolition Wagon.	II. Sec. 12 Store Wagons.	III. Sec. 1 Entrenching Tool Wagon.	III. Sec. 1 Demolition Wagon.	III. Sec. 12 Store Wagons.	IV. Sec. 1 Entrenching Tool Wagon.	IV. Sec. 1 Demolition Wagon.	IV. Sec. 1 Small Store and Tool Wagon.	IV. Sec. 12 Store Wagons.	1 Baggage Wagon.
Earthwork	Axes, pick	55	30	1	150	—	—	—	—	—	6	—	50	1	700	50	1	700	50	1	700	50	1		700	
	Shovels,[2] large	44[1] 110 88[1]	60	2	600	—	—	—	—	—	13	—	200	2	800	200	2	800	200	2	800	200	2		800	
Carpentering, for Bridge work.	Axes	58	20	—	90	3	6	—	—	—	8	12	30	—	100	30	—	100	30	—	100	30	—		80	
	Hatchets	45[1] 22 18[1]	1	1	3	2	4	1	2	—	3	1	—	1	125	—	1	125	—	1	125	—	1		125	
	Lashings	—	120	30	—	32	64	30	—	—	—	200	—	30	—	—	30	—	—	30	200	—	30		200	
	Pencils, carpenters'	—	12	6	36	12	24	—	—	—	—	6	12	6	—	12	6	—	12	6	—	12	6		—	
	Plummets and lines	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	
	Field Forge with tools	—	—	—	—	1	2	—	—	—	—	—	6	—	—	6	—	—	6	—	25	6	—		25	
	Saws, hand, sorts	—	8	—	18	2	7	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—		—	
	Clamps, iron	—	50	10	30	60	60	—	—	—	—	50	10	10	—	10	10	—	10	10	—	10	10		—	
	Hammers, flogging	—	2	—	6	—	—	—	—	—	—	4	2	—	—	2	—	—	2	—	—	2	—		—	
	Pincers and Tongs, wire	—	9	1	12	2	4	—	—	—	—	2	4	1	—	4	1	—	4	1	25	4	1		—	
	Hammers, hand, sorts	—	6	1	24	2	8	—	—	—	—	4	8	1	—	8	1	—	8	1	—	8	1		—	
	Gimlets	—	12	6	18	3	8	—	—	—	—	3	6	6	—	6	6	—	6	6	29	6	6		29	
	Nails in bundles of 60	—	10	5	—	10 k.g.	20 k.g.	5	—	—	—	10	—	5	—	—	5	—	—	5	25	—	5		25	
	Mauls	—	—	—	12	—	4	—	—	—	—	2	3	—	—	3	—	—	3	—	5	3	—		5	
	Augers (shell and spoon)	—	2	—	30	4	8	—	—	—	—	2	10	—	—	10	—	—	10	—	—	10	—		—	
	Stocks, taps and dies	—	—	—	—	1[4]	2[4]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	
	Saws, pit and rip	—	6	—	12	1	3	—	—	—	—	2	4	—	—	4	—	—	4	—	5	4	—		5	
	Swimming dresses	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—		—	
	Chisels of sorts	—	4	3	18	4	10	—	—	—	—	4	6	3	—	6	3	—	6	3	—	6	3		—	
	Axes, hand	—	2	—	6	—	—	—	—	—	—	—	2	—	—	2	—	—	2	—	—	2	—		—	
	Blocks, pairs with tackle	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—		—	
	Cables, 65 m.	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—		—	
	Pickets, park	—	—	—	12	—	2	—	—	—	—	2	4	—	—	4	—	—	4	—	5	4	—		5	
	Lines, tracing and carpenters'	—	6	—	9	1	2	—	—	—	—	4	3	—	—	3	—	—	3	—	5	3	—		5	
	Rods, measuring, 2 mètre	—	3	1	9	1	2	—	—	—	—	2	3	1	—	3	1	—	3	1	5	3	1		5	
Demolitions	Bars, crow	—	6	3	—	1	2	—	—	—	—	2	—	3	—	—	3	—	—	3	—	—	3		—	
	Cutters, wire	—	12	—	—	—	—	—	—	—	—	—	—	—	75	—	—	75	—	—	75	—	—		75	
	Punches	—	—	4	—	—	—	—	—	—	—	—	—	4	—	4	—	—	4	—	—	4	—		—	
	Hammers, miners'	—	—	3	—	—	—	—	—	—	—	—	—	3	—	3	—	—	3	—	—	3	—		—	
	Chisels, cold	—	—	10	—	—	—	—	—	—	—	—	—	10	—	10	—	—	10	—	—	10	—		—	
	Hammers, platelayers'	—	—	4	—	—	—	—	—	—	—	—	—	4	—	4	—	—	4	—	—	4	—		—	
	Spanners, shifting	—	—	2	—	—	—	—	—	—	—	—	—	2	—	2	—	—	2	—	—	2	—		—	
	Bars, boring, sets	—	—	3	—	—	—	—	—	—	—	—	—	3	—	3	—	—	3	—	—	3	—		—	
Explosives and their Appliances.	Cartridges, explosive 88	—	—	286	—	—	—	36	—	1752	—	—	—	286	—	286	—	—	286	—	—	286	—		286	
	Wire box with drum	—	—	1	—	—	—	—	—	—	—	—	—	1	—	1	—	—	1	—	—	1	—		1	
	Dynamo and testing cell	—	—	1	—	—	—	—	—	—	—	1	—	1	—	1	—	—	1	—	—	1	—		1	
	Fuzes, electric	—	—	100	—	—	—	100	—	600	—	25	—	100	—	100	—	—	100	—	—	100	—		100	
	Bags, rubber	—	—	12	—	—	—	12	—	—	—	5	—	12	—	12	—	—	12	—	—	12	—		12	
	Tubes, rubber forked (for jointing)	—	—	10	—	—	—	10	—	—	—	—	—	10	—	10	—	—	10	—	—	10	—		10	
	Wire, insulated guttapercha	—	—	600	—	—	—	200	—	—	—	300	—	600	—	600	—	—	600	—	—	600	—		600	
	Fuze, guttapercha (Bickford)	—	—	200	—	—	—	200	—	1200	—	100	—	200	—	200	—	—	200	—	—	200	—		200	
	Insulators	—	—	50	—	—	—	—	—	—	—	—	—	50	—	50	—	—	50	—	—	50	—		50	
	Props for ditto	—	—	50	—	—	—	—	—	—	—	—	—	50	—	50	—	—	50	—	—	50	—		50	
	Wire, copper, plain	—	—	600	—	—	—	—	—	—	—	—	—	600	—	600	—	—	600	—	—	600	—		600	
	Sandbags	—	—	20	—	—	—	20	—	—	—	—	—	20	5000	20	8000	—	20	5000	—	20	—		20	12000
	Fuzes, detonating	—	—	100	—	—	—	100	—	—	—	—	—	100	—	100	—	—	100	—	—	100	—		100	
	Fuze, instantaneous	—	—	200	—	—	—	200	—	1200	—	50	—	200	—	200	—	—	200	—	—	200	—		200	
	Caps, detonating	—	—	200	—	—	—	200	—	1200	—	200	—	200	—	200	—	—	200	—	—	200	—		200	
	Charges, detonating 88	—	—	1800	—	—	—	2160	—	10800	—	1080	—	1800	—	1800	—	—	1800	—	—	1800	—		1800	
	Fuzes for ditto (Cavalry)	—	—	—	—	—	—	—	—	300	—	—	—	—	—	—	—	—	—	—	—	—	—		—	
	Wallets, tools, complete	—	—	1[5]	—	—	—	—	—	—	—	2[6]	—	1[5]	—	1[5]	—	—	1[5]	—	—	1[5]	—		1[5]	
	Fuzees	—	—	100	—	—	—	100	—	—	—	—	—	100	—	100	—	—	100	—	—	100	—		100	

Tools and materials for carpenters, joiners, wheelwrights, saddle and harness makers, smiths, tinsmiths. Surveying and drawing gear.

[1] Company 200 strong.

[2] The shovels have straight long handles with knob at end.

[3] Also 1 Horner reflector in entrenching tool wagon.

[4] From 6·5 to 23 m.m. screw.

[5] Holding 1 cutting pliers, 3 flat pliers, 2 clamping pliers (for pinching detonator on to fuze), 1 scissors, 1 knife, 2 rolls iron binding wire

[6] Holding 1 cutting pliers, 1 flat pliers, 1 clamping pliers, 1 scissors, 1 knife, 2 rolls iron binding wire, 1 file, 1 copper hammer, 1 awl.

TRANSCRIPT.

EXPLORATION AND SURVEY WITH THE TIBET FRONTIER COMMISSION, AND FROM GYANGTSE TO SIMLA *VIÂ* GARTOK.*

By Major C. H. D. Ryder, d.s.o., R.E.

I. The Main Expedition.

It has been said that the geographical results of the expedition to Lhasa have been disappointing. No one was better pleased than myself that this was in a sense true. Our knowledge of the country lying between our frontier and Lhasa depended chiefly on the surveys executed by different explorers trained by and working under the supervision of officers of my department—the Survey of India. They worked under extraordinary difficulties, and in great danger of their lives. That, when at last we have been able to carry through a regular and systematic survey of the country, we have not been able to find that the rough maps prepared from these explorers' surveys were in any important points other than very fairly accurate, reflects the very highest credit on these men, notably the late Pandit Nain Singh and the explorer A.-K., the latter of whom is still alive. In place of these rough maps, we have now an accurate survey of the country traversed by the expedition.

On September 24th, 1903, I received orders at Bangalore to join the Tibet Frontier Commission at Kampa Dzong. Proceeding *viâ* Calcutta, where I had to spend a few days collecting instruments and kit, I arrived at Silliguri, the railway base, on October 3rd, and marched out the same afternoon to Sevoke, where the Teesta leaves the hills. This was not the time of year to see the Teesta valley at its best; very hot, raining nearly every day, the march up the valley was far from pleasant, The cart road, now open as far as Gangtok, was then constantly blocked by landslips, and very slippery. After Gangtok was passed the views of the snows should have been magnificent, but the higher hills were veiled in clouds. All the more pleasant, therefore, was the marked change once the frontier pass, the Kangra La, was crossed; clouds were left behind, and during the two months I stayed at Kampa Dzong we

Kampa Dzong.

* Letterpress and map reprinted by permission from *The Geographical Journal.*

had nothing but the finest weather, with that wonderful clear atmosphere which every traveller in Tibet has remarked on.

Down the long slope from the Kangra La, and over the rolling downs near the valley of Giri, the great snowy range gradually opened out, till on reaching Kampa Dzong, or at any rate from the hill above it, one continuous line of snows was visible stretching from Chumolarhi to Mount Everest, a distance of some 150 miles. We were able to survey from this snowy range northwards to the Arun river—Tsangpo watershed—the Tibetans, beyond sending men to watch us, making no attempt to stop us surveying so long as we did not camp away from the mission post.

As regards the heights of peaks, our results were of a negative nature. The highest point on the above-named watershed was 20,100 feet; the two "very high snowy mountains" mentioned by Mr. Freshfield on p. 362 of the *Geographical Journal* for March, 1904, quoting from one of the explorers, were disappointing, being only 21,200 feet in height. The fine snowy range apparently running north from Everest, in reality running north but some 30 miles east of Everest, has its highest summit at an elevation of 22,200 feet. The northern side of Everest has a continuous slope, which I estimated at 7,000 feet; and it is extremely unlikely that north of Everest, and hidden by the nearer snowy range, the peaks could again rise to a height anywhere approaching that of Everest. It is interesting here to note that Everest, as viewed from Kampa Dzong, does not appear as the highest peak of a group, but as one massive summit standing by itself. Nowhere could we hear of any local name for Everest, although careful inquiries were made. The height of Kampa Dzong itself proved to be 15,200 feet, instead of 13,800 as on previous maps.

Chumbi Valley.

Fortunately, just as we had completed all the surveying possible from Kampa Dzong under existing circumstances, it was decided that the Mission should retire from Kampa Dzong and advance over the Dzelap La and up the Chumbi valley. We accordingly hurried across Sikhim, and caught up the main body of the Mission and its escort at Chumbi. This valley is disappointing; it has always had a great reputation, but we found it to be only 200 or 300 yards wide, and not very rich. The houses at Rin-chen-gong are good, but that is not due to any richness in the valley itself, but to the fact that the Tomos, the inhabitants of the valley, have a monopoly of the carrying trade from Phari Dzong down into Sikhim.

A short halt here enabled me to get the lower end of the valley surveyed; and to detach Sub-Surveyor Dalbir Rai, who followed the valley down to the plains, and, returning to Gnatong by the adjoining valley, completed a most useful piece of work, including a hitherto unsurveyed portion of Bhutan.

The Mission then moved up to Phari Dzong and over the Tang La (15,200 feet), a very easy pass, to Tuna (14,800 feet). Here we spent the winter, and, except for some work in the Chumbi valley, surveying was nearly at a standstill; the Bhutan snowy range on the east, lower rounded hills on the west, and the Tibetan force at Guru, 6 miles north of

us, limited our sphere of observation. The cold was intense, and a very unpleasant three months were spent before we again advanced. Towards the end of March Mr. Hayden, of the Geological Survey, and I, with an escort of twenty rifles, made a short excursion across the plain to explore the Lingshi La, a pass crossing the snowy range into Bhutan. Before, however, reaching this point, we were met by a small Tibetan force and requested to return. In view of my knowledge that Colonel F. Younghusband (the Commissioner) was very anxious to avoid, if possible, a collision with the Tibetans, I decided to retire to Tuna.

Brigadier-General J. R. L. Macdonald, R.E., and the main force having arrived at Tuna, it was decided to make a preliminary advance to Guru, where the Tibetans were encamped, and establish a post there. Unfortunately for them, the Tibetans decided to oppose our advance. A short fight took place, in which the Tibetans suffered heavily. On 2nd April Capt. H. McC. Cowie, R.E., joined us, just in time for the advance to Gyangtse, which took place on April 4th.

We camped on April 4th at Guru; we then marched round the shore of the Bam Tso to Chalu, and the following day did a short march down the narrow valley along which the stream flows connecting the Bam Tso with the Kala Tso. I ascended a point on the range between the two lakes, and had a fine view down on to both of them. The Bam Tso has an area of about 25 square miles, and the Kala Tso of about 15 square miles. Next day, April 7th, we had a level march to Mangtsa, where the open country ends. There is no outlet to the Kala Tso, but there are obvious signs that in ancient times the water flowed out of the lake into the narrow gorge, and so to Gyangtse and the Tsangpo. About 8 miles from the lake in this direction a small stream rises from what is probably an underground flow from the lake, and flows in a broad and deep bed down the gorge.

From Mangtsa the force marched to 3 miles short of Kangma, down a narrow gorge, while Capt. Cowie and I ascended the range to the east to a height of about 18,000 feet, to try and get a view ahead. In this we were not successful, still higher hills on the north on both sides of the gorge blocking our view. The Tibetans were reported by the mounted infantry to be in force holding a wall across the valley at Kangma; but next day their position, a strongly built wall, which, however, could have been easily turned, was found evacuated. Next day they were located in a position holding a narrow gorge, known as the Red Idol gorge, and the precipitous hills on either side. Out of this they were easily turned by a direct attack and a long flanking climb on the part of the Gurkhas. We camped at Sapu that evening, and marched on to the Gyangtse plain the following day. On April 11th the dzong, or fort, of Gyangtse was surrendered by the Tibetans, who seemed cowed by the defeats they had received. The Mission was established in a village on the right bank of the Nyang Chu, where there is a bridge, and about 1,000 yards from the dzong.

Gyangtse.

A force under Colonel Brander was left as escort, while the General and the main force returned to the Chumbi valley, leaving posts at Kangma, Kala Tso, and other places on the line.

We now settled down to a peaceful existence. A bazaar was established outside the post, and officers in small parties could wander about the plain shooting.

Capt. Cowie and I were then able to start triangulation off a measured base, and, with the help of three stations on the hills, we completed all the work that was possible. We were not then able to connect this triangulation with my Kampa Dzong and G.T. peaks, but we fixed some peaks on the Karo La range, which afterwards proved invaluable in connecting the Lhasa triangulation with this work.

Towards the end of the month a report came in that a force of Tibetans had collected on the Karo La, 45 miles from Gyangtse on the road to Lhasa. A party, consisting of fifty men of the 32nd Pioneers and thirty mounted infantry, under Lieut. Hodgson, was sent out to verify this report. As this would afford an opportunity of getting in a good addition to our map, I decided to accompany the party with Capt. Cowie.

We reached Ralung, two long marches from Gyangtse, on April 29th, and the following day, accompanied by the mounted infantry, rode up to the pass, about 2 miles beyond which we saw the wall which the Tibetans had built. Lieut. Hodgson took a few men forward to draw their fire and make them disclose their strength. In this he was successful, and, withdrawing his men without loss, although some Tibetans concealed on the hills above were rolling rocks down on him, we rode back to Ralung. I had intended taking the mounted infantry to Kangma in one long day's march, as it was important to have this route reconnoitred, but, owing to the presence of the Tibetans in such force on the Karo La, this was not now considered advisable, and we returned to Gyangtse in two marches, arriving there on May 2nd.

Colonel Brander decided to take out a force to turn the Tibetans out of their position on the Karo La, as they were threatening our line of communications. On May 3rd he accordingly started, Capt. Cowie again accompanying, as I hoped he might be able to get the route from Ralung to Kangma done this time. They attacked the Tibetans on the 6th, and drove them out of their position, but, owing to our having in the meantime been attacked at Gyangtse, Capt. Cowie had to return with the force.

On the 4th everything at Gyangtse seemed peaceful. I had been out for a long day surveying on the hills to the south, and on my return heard of a report, originating from one of the patients in Capt. Walton's civil hospital, that we were to be attacked next day. A small mounted infantry patrol went some miles down the Dongtse road, but found nobody. The Tibetan force, however, was at Dongtse itself, and, leaving when the moon rose about 1 a.m., attacked us just after dawn. Their attack was a complete surprise, but once our men turned out, the Tibetans were easily driven off with heavy loss. If, however, the Tibetans had not given the alarm by shouting and firing their guns, but rushed in with their swords, we should have been in a rather awkward position. Another force of theirs had in the meantime occupied the dzong, from whence they opened a heavy fire, which, to everyone's surprise, more than reached our post. The fighting in and around Gyangtse has been

already often described; it culminated in the capture of the dzong on July 6th.

Capt. Cowie and Surveyor Sher Jang, who had come up with the relief force, now rejoined me, and on July 14th we commenced our march to Lhasa. Owing to the cloudy weather rendering triangulation impossible, I thought it advisable, in case we could not afterwards connect Lhasa and Gyangtse by triangulation, to run a subtense bar traverse; this entailed Capt. Cowie and I being on the road all day, starting with the advance guard and getting in in the evening. The weather, too, was very bad, heavy rain falling almost every day, effectually dispelling the prevailing notion that this part of Tibet is a rainless country. To Lhasa.

The Karo La (16,200 feet) was crossed on July 18th, the bulk of the Tibetans holding the position bolting the night before from the wall in the valley, leaving their companions on the hills to their left to escape as best they could. They were easily driven out of their position by the 8th Gurkhas, who established a record in hill fighting at high altitudes, the Tibetan position reaching an elevation of 18,500 feet and their retreat leading across the face of a glacier.

The next day the force moved to Nangkartse Dzong, in sight of the Yamdrok Tso. The snow-peak marked in former maps in the centre of the promontory, round which the Yamdrok Tso makes an almost complete circle, is a myth. No hill there has permanent snow, though, as their height is about 17,000 feet, there doubtless is often snow lying there when there is none at Nangkartse Dzong or on the shore of the lake (14,350 feet). After a day's halt we marched to Yarsik, where the original outlet of the lake obviously existed. We then marched for two more days along the shores of the lake, which all along this part is never more than 2 or 3 miles wide, and very often less.

We crossed the Kampa La (15,400 feet) on the 24th, an easy ascent from the lakeside but a very long drop down to the Tsangpo. Owing to the low elevation (11,550 feet) and Sarat Chandra Das's description, I thought that the valley would have been well wooded; this, however, was not so; the hills were quite bare, and no trees grew wild, though round every village there were fine groves. We moved on 6 miles down the river to the place selected for the crossing, where the Tibetans had kindly left a large ferry boat on our side of the river.

The whole force had crossed on the 30th, a very laborious process. The valley here is broad and well cultivated, the river running in most places in several broad channels with sandy islands in between. It was about at its highest flood-level soon after we had all crossed, with a very fast current and deep, and 140 yards wide.

On July 31st we moved off, and after a few miles turned up the Kyi Chu, a well-cultivated valley with a broad shallow river resembling the Tsangpo valley on a slightly smaller scale.

On August 2nd we arrived at the Tolung Chu, a large affluent of the Kyi Chu, and over which there is quite a good bridge. From here we were rewarded by our first sight of the Potala, the residence of the Dalai Lama, situated on a small isolated hill overlooking Lhasa.

Lhasa. Next day camp was moved to within a mile of the Potala; this was, however, only a temporary camp, and, being swampy, another site was selected on drier ground north of the town, the Mission being located in a very good house in pretty wooded grounds outside the town. The weather was not favourable for surveying—rain fell constantly, and heavy clouds lay on the surrounding hills; so Capt. Cowie and I confined ourselves, after measuring a base and observing a latitude and azimuth, to the survey of the town and suburbs of Lhasa on the scale of 6 inches to the mile. This took some time, as we were at first not allowed to enter the town itself; but later on, having got in all the somewhat extensive groves, gardens, and summer residences outside the town, we were allowed to march through the streets with an escort. In order to avoid attracting attention, for this portion of the work we did not use a plane-table, but made a compass and pace traverse from one fixed point outside through to another fixed point on the other side. The inhabitants showed some curiosity, but no hostility, at our proceedings. The height of the plain above sea-level is 11,830 feet. Capt. Cowie left Lhasa on August 29th for Gyangtse, to try and secure the connection in the triangulation between that town and the points I had fixed from Kampa Dzong. The weather now began to improve; and I was able to go out with a small escort, firstly, up the valley a day's march, from whence I took mounted infantry up to the junction of the Penbo Chu with the main valley, just opposite the Garden Monastery and some 30 miles from Lhasa; and, secondly, up the Tolung Chu, a somewhat similar expedition.

Having done these two trips, there only remained to go up on to the Penbo La, the pass on the main road leading north from and about 10 miles from Lhasa. This was important for the triangulation, and I was lucky to do all that was necessary in a short spell of fine weather, which just coincided with the five days I spent in camp at the foot of the pass, climbing an 18,000-foot hill each day.

From this range we were able to sketch in carefully the adjoining valley to the north, a broad, well-cultivated, and thickly populated plain; and from three stations I was able to connect on with the peaks of the Karo La range, and also to fix many points north and eastwards, including some fine snow-peaks south of the Tengri Nor, mentioned by Mr. Littledale, the highest of which was 23,250 feet in height and the highest peak we ever came across north of the Tsangpo. Two other snow-peaks which I fixed are, I believe, those mentioned by M. Bonvalot, and christened by him Mount Huc and Mount Gabet; but their heights were disappointing, the highest being 21,500 feet.

Return from Lhasa. The treaty had been formally signed at the Potala on September 7th, and on the 23rd we left on our return march. On this occasion we recrossed the Tsangpo 10 miles higher up, and crossed the range between it and the Yamdrok Tso by the Do La, 16,000 feet, a long steep climb from the river. From this pass, the weather being clear, I had a fine view, and was able to fix a station by observations to peaks on the Karo La range and to two Bhutan peaks, already fixed from India, being also able to see and observe to one of my stations on the hills north of Lhasa. I had gone on ahead of the main force, with an escort of one hundred Gurkhas

under Major Row. Next day we marched along the lake to Yasik, and I went up on to the range again, and, observing from two more stations, completed a good area of triangulation, and secured the required connection between the triangulation done from Gyangtse and that done at Lhasa.

At Yasik on September 30th we met Capt. Cowie, who, though much hampered by the cloudy weather, had effected a satisfactory connection between the Gyangtse triangulation and the Kampa Dzong work. We here struck off the main route up the side valley, across a very low, in fact almost inappreciable, watershed, and followed down the narrow valley, known lower down as the Rong Chu, which flows into the Tsangpo. I have no doubt whatever that this is the old outlet of the Yamdrok Tso, which now is landlocked. Next day we left the valley, camping near the Nyadong La (16,000 feet), crossed the pass next day, and so on to the plain above Ralung. This survey was useful, in that it showed the possibility of turning the Karo La. Capt. Cowie then made a round from Ralung into the Niru valley, down to Gobshi, and so to Gyangtse, while I caught the General up on the main road and accompanied the main force. I now made arrangements for Capt. Cowie to complete the work remaining between here and Chumbi, on which he writes as follows :—

"On October 8th, with Sub-Surveyor Hazrat Ali and a portion of the survey detachment, I left Gyangtse for Kangma, which was reached next day. Commencing a route-survey from this village on the 10th, we struck off the line of communications, marching eastwards through a narrow defile in the bare rocky hills dividing the waters of the Nyang Chu and the Niru Chu. As far as the Nilung La, which we crossed the same day, we followed the track which is part of the main road from Kangma to Ralung *viâ* the Wogya La. After crossing this pass and descending into the open plain, which receives the headwaters of the Niru Chu, we turned southwards, heading for the Rham Tso. Passing over the low rolling hills which intervened, we reached the lake on October 14th, completing the survey of this locality, and fixing the position of the Yu Tso, a lake lying at the foot of the snowfields of the big range culminating further to the south-west in Chumolhari. On the 14th I got into communication with the headquarters staff, who had just reached Kala Tso, and, for the purpose of adding to the half-inch survey of the Khambu valley, obtained sanction to strike off the line of communication at Tuna, and, crossing a pass some 12 miles west of the Tang La, to follow the course of Khambu Chu, eventually rejoining the line at Chumbi.

"Surveyor Sher Jang, who had accompanied the force from Gyangtse as far as Kala Tso, joined me at Chalu on the 14th. On the 16th we left Tuna, taking with us from there a Tibetan who professed to know the hills to the east of Powhanri, and camped in the small valley below the pass.

"On the evening of the 16th snow began to fall, and by the 17th and 18th a severe blizzard had set in. We left camp on the 17th in the midst of it, purposing to cross over into the Khambu valley, but were unable to

reach even the pass. In consequence of mist and the thick driving snow it was impossible to see more than a few yards in any direction; we had no track to guide us, and the snow was nowhere less than 2 feet deep. The difficulties of progressing were great, and in addition we, the guide included, lost our way. Though only a few of the party were frost-bitten, many had begun to suffer from snow-blindness. Finding it impossible to proceed, with much trouble we eventually got back on the 18th to a point near our camping-ground of the 16th. Next day, with over 50 per cent. of the party incapable from snow-blindness, we crossed the Tang La and reached Phari in the evening. On the 22nd I reached Chumbi, and reported to the G.O.C. (the telegraph line having been broken by the storm), who had sent out a search party for us from Chumbi.

"All of the party had recovered from snow-blindness and the effects of exposure sufficiently to move to Chumbi on the 26th. The whole of the survey detachment left Chumbi on the 28th, and, marching *viâ* the Nathu La and Gangtok, reached Siliguri on November 5th."

Survey Results.

The survey results of the expedition are as follows:—

Triangulation.—An area of 45,000 square miles was completed, connecting Lhasa with India, and fixing all prominent peaks which were visible, with their heights.

Topography.—An area of 17,000 miles was surveyed on the scale of 4 miles to the inch, of which 3,000 square miles, in the neighbourhood of the Chumbi valley, Gyangtse, and Lhasa, were also surveyed on the scale of 2 miles to the inch.

Route surveys, on the scale of 1 inch to the mile, were made of the road to Lhasa.

Large-scale plans were also made of the towns of Gyangtse and Lhasa.

II. FROM GYANGTSE TO GARTOK.

When the treaty was signed at Lhasa on September 7th, 1904, it was decided that a party should proceed to Gartok to examine the place, as is was one of the trade-marts which the Lhasa Government had decided should be opened in Tibet. It was obvious that this would afford a great opportunity of adding to our geographical knowledge of the country. The ostensible object of the journey being a political outcome of the treaty, Capt. Rawling, of the Somersetshire Light Infantry, who in 1903 had made a remarkable and useful journey in Western Tibet, and who was now deputed to open the trade mart at Gartok, was placed in general control of the expedition. He was assisted by Lieut. Bailey, 32nd Pioneers, one of the few officers who have acquired a knowledge of the Tibetan language, which proved very useful to us; the survey party consisting, besides myself, of Capt. H. Wood, R.E., and Sub-Surveyor Ram Singh, R.S.

In making our arrangements for the journey, two considerations were paramount—firstly, that we should be having a race against winter, with a possibility that, should we be unable to get over the passes into India

before the winter snow fell, the unpleasant prospect would have to be faced of having to winter at Gartok or some equally cold and inhospitable spot; secondly, it was quite impossible to tell whether and to what extent the Tibetans would assist us. Fighting had only lately ceased, the treaty had been signed barely a month previously, and there had been no opportunity of seeing whether the Tibetans would adhere to the treaty when our troops were withdrawn to India.

Our time for preparation was very short, every day's delay increasing the probability of our being snowed up. Capt. Wood and Lieut. Bailey arrived at Gyangtse, which was to be our starting-point, on September 30th, while Capt. Rawling and I only reached the same place on October 6th and 5th respectively.

Our transport we organized as follows:—Twenty-six baggage ponies to give us a nucleus of our own, should the Tibetans make difficulties about providing us with animals; seventeen riding ponies, it being important that, in view of long and continuous marching at a high elevation, as many men as possible should be mounted; one hundred yaks, lent to us from one of the transport yak corps to take us to Shigatse, but not to go beyond that town. From there onwards, however, the Tibetans invariably, and without any demur, provided us with whatever transport we required. Ponies, donkeys, mules, yaks, and coolies at various times carried our baggage, and, although it was difficult to supervise so large and mixed a caravan, no single article was lost during the whole time the journey lasted.

We took two months' supplies for all our men, with two months' extra of such things as ghi, goor, etc., which could not be obtained *en route;* while for the officers' mess we took four months' stores. Meat we could rely on obtaining in abundance, and tsamba or parched barley flour as long as we came across villages.

Our party was finally organized and ready to start on October 9th as follows:—

Capt. C. G. Rawling, Somersetshire Light Infantry; Capt. C. H. D. Ryder, R.E., Survey of India; Capt. H. Wood, R.E., Survey of India; Lieut. F. M. Bailey, 32nd Pioneers; Sub-Surveyor Ram Singh, R.S.; hospital assistant Hira Singh; three military surveyors; five sepoys of the 8th Gurkha Rifles; five survey khalassies; seven pony-drivers; two Hindustani servants; two Tibetan servants; Mahomed Isa, a Ladakhi, who acted as caravan leader; and last, but not least, a very small Lhasa Blenheim spaniel, who followed our fortunes throughout.

In order to have the advantage of the company of Capt. O'Connor, who was remaining as trade agent at Gyangtse, and who, with two other officers, was making a trip to Shigatse, we postponed our departure till the 10th.

Shigatse.

Our first day's march took us to Dongtse, the late headquarters and supply depôt of the Tibetan army which had attacked the Mission and its escort for two long months at Gyangtse; but here, like everywhere else, we were cordially received—mainly, I fancy, owing to our being accompanied by a Lhasa official, who had been deputed to escort us to Gartok, and also to our being supplied with a very strongly worded

permit, signed with the seals of the Lhasa Government and of the three great Lhasa monasteries, and directing all officials along the route to render every assistance.

Three more marches, following the valley of the Nyang Chu, which is one of the richest and most prosperous valleys of Tibet, landed us at Shigatse on October 14th. Here we spent several busy days with an army of tailors, making warm clothing for ourselves and our men, lining all coats with lambskins, making fur caps and gloves, etc., till finally, when fitted out, we presented an appearance akin to Arctic explorers. Our stay at Shigatse was not, however, all work. We paid a most interesting visit to the great Tashi Lhunpo monastery, where the monks received us most cordially, showing us all over the place, and finally giving us refreshments of tea, cakes, and dried fruits. This monastery is said to contain four thousand monks, and although not so large as, is richer than, the great Lhasa monasteries. The bulk of the buildings, the residences of the monks, were of the usual type—narrow paved roads with high houses on each side, dirty, and not picturesque. But we also enjoyed the sight of the tombs of the five previous Tashi lamas, each a separate building with its golden roof and highly ornamented interior, filled with a wealth of turquoises, gold bowls, and rare old jade and cloisonné, the effect being somewhat marred by a foreground of small vessels holding lighted tapers fed by very evil-smelling butter. Bogle's description of his visit is very picturesque and accurate; the number of tombs has now, however, increased from three as seen by him to five as seen by us.

We were fortunate, also, in being received by the Tashi Lama, who, after holding an almost co-equal position to the Dalai Lama, has now, by the disposition of the latter, become the most important ecclesiastic in Tibet. He was living in his summer residence, a house outside the town, to which, with Capt. O'Connor as political officer at our head, we proceeded. A little hitch occurred at the gateway, as an arch-scoundrel, Colonel Ma, who had been the Chinese official at Gyangtse when we were attacked, and had never given us warning nor even tried to protect the servants and property of his colleague, Capt. Parr, was also paying a visit. Capt. O'Connor refused to enter the house while this individual was in it, and the latter had to be smuggled out by some back door. We were then shown up some steps and along dark passages till we arrived at the reception-room, at the far end of which we could see the Tashi Lama seated cross-legged on cushions on a raised platform. He received us each with a bow and a smile, which we returned; and we were then shown to seats on one side of the room, while the other side was filled with Tibetan officials and monks in either the ordinary maroon-coloured clothes usually worn by monks or in the yellow silk of the higher temporal officers. Tea, undrinkable as usual, was handed round, but on this occasion it had a certain glamour attached, due to its being served in enormous teapots of gold and silver. Dishes laden with sweetmeats and dried fruits were also brought in, but soon hurriedly removed and handed over to our followers.

While Capt. O'Connor was exchanging civilities with the Tashi

Lama, we had time to think of the sudden change from a few months before, when the Tibetans, amongst whom was a strong contingent from this very place, Shigatse, were attacking us at Gyangtse, to the present moment, when we, a few unarmed officers, were sitting in amity with our quondam enemies. The Tashi Lama himself is an interesting personality; sixth holder of the office, his face is one that would not pass unnoticed anywhere, still less in Tibet. He has clear-cut features, high cheek-bones, and a pale complexion; his quiet dignified manner made a lasting impression on us. His age is only about twenty-three, and he seemed generally beloved and revered. During the whole of our visit a slight and pleasant smile never left his face. After silk scarves had been presented to us and our Tibetan followers had been blessed, we left, with the feeling, due partly to the personality of the Lama himself, partly to the room with its dim light, that we had been assisting at some religious ceremony.

We had commenced our survey at Dongtse, one march from Gyangtse; and as we wished to keep up triangulation, Capt. Wood and I left Shigatse on October 17th to do two short marches, the rest of the party leaving a day later and doing the two marches in one. Owing to bad weather, which gave us some rain and covered the surrounding hills with snow, we were unable to reach our hill, so decided to halt a day at Kangjen Gompa, a most delightful camp in a grove of trees. This was the same storm which entailed such hardships on our force returning to India in the neighbourhood of Phari Dzong. Fortunately for us, we were here at the lowest point of our journey, the height of Shigatse being 12,570 feet, and escaped with only slight inconvenience.

By visiting these hills, one of which was over 18,500 feet in height, and from two of which we had fine views of Mount Everest, Capt. Wood was enabled to carry on the triangulation under very adverse circumstances. To climb one of these hills is itself a hard piece of work; to observe at the top in a bitter wind is one of the most physically painful operations I have ever experienced. To do this in combination with a day's march leads to a very long and hard day's work. Capt. Wood carried this on for days and months with hardly any intermission—a feat which could only have been accomplished by an officer of his energy and determination.

Up the Tsangpo.

Until we reached Pindzoling, on October 22nd, the river had been a few miles to the north of our route, but from thence we followed the river more closely. Two more marches and we were at Lhatse Dzong; a dzong or fort on a small rocky hill, very similar to those at Shigatse and Gyangtse, surrounded on one side by the river and on the others by a fair-sized monastery and a small town. The valley here widens out into a plain, cultivated in parts, barren elsewhere. At Lhatse Dzong we halted a day, which enabled Capt. Wood and I to ascend a hill a few miles east of the town, overlooking a broad bare valley which leads to the very famous Sakya monastery. We regretted that want of time, and the consideration that it was not advisable to divide into two parties until we had thoroughly tested the friendly disposition of the Tibetans, had prevented us from paying a visit to this monastery.

From Lhatse, however, the Tibetans having shown no desire but to assist us in every way, we decided to separate. While Capt. Wood and Lieut. Bailey followed the main route, which here crosses and leaves the river, Capt. Rawling and I stuck to a route reported to follow up the south bank, as I did not wish, if possible, to omit any portion of the river from our survey.

Accordingly, on the 26th we parted company, camping that night on opposite sides of the valley, which now closed in. We kept to the river the following day, but on the 28th we had to leave it, and for two marches followed up a side stream, the Chi Chu, running parallel to and only 2 or 3 miles distant from the Tsangpo, which we again rejoined on the 30th. On November 1st we could see that the river ran between rocky hills with snow-peaks on either side, and had to leave it, making a wide *détour* to the south. We marched up a side nullah, camping in bitter cold at nearly 16,000 feet, and crossing the Kura La, a very desolate pass, next day, at an elevation of 17,900 feet. Marching across the head of a plain which forms the headwaters of the Chi Chu, previously mentioned, we passed over an almost imperceptible watershed down a narrow stony valley to the village of Kaju. We had had a magnificent view of the main Himalayan range from a hill a few hundred feet above the pass. Mount Everest stood up towering above the rest of the range in its neighbourhood in one isolated peak, a continuous drop of some 8,000 feet separating it from the rest of the range east and west of it. The village of Kaju (14,800 feet) lies on the edge of the Sutso Tang plain, which takes its name from an old ruined fort on a small eminence in its centre. It is here about 5 miles wide, and we could see it trending away southwards and joining the Dingri maidan, which lies north of Mount Everest. A day's halt here enabled me to cross this plain, from the hills on the western side of which I obtained an uninterrupted view of Mount Everest, no hills intervening. I was thus able to satisfactorily establish the fact, which I had suspected a year before at Kampa Dzong, that no peaks anywhere approaching the height of Everest exist to the north of it or anywhere in its neighbourhood; it stands alone in its magnificent solitude, and is entirely disconnected from the mass to the west, of which Peak XX. (Gaurisankar) is the best-known point; on the south-east of Everest, but separated from it by a low gap, lies Peak XIII. (Makalu). We were here in the valley of the western branch of the Arun or Kosi river, but, recrossing the watershed next day by the Sheru La (17,600 feet) we once more reached the banks of the Tsangpo on November 5th. The scenery was now changing; trees we had said good-bye to some marches back, our last cultivation we passed that day, while the hills were becoming more open and the plains abounded in sand-dunes. Brushwood was in places available for fuel, but we preferred argol, or dried yak-dung, as it gave greater heat, and, if the fire was carefully looked after, less smoke. During the whole of this portion of the river journey we had seen no four-footed game other than numerous hares, and a few gazelle on the Sutso Tang plain; but birds we saw and shot numbers of, Tibetan partridge (ramchikor) and Tibetan sand-grouse giving us a welcome change in our otherwise monotonous fare of mutton.

On the 6th we crossed to the north bank of the river with the utmost difficulty. A crazy-looking punt, manned by lamas, took us across in detachments; but, owing to the masses of floating ice whirled down the river by the rapid current, the punt was repeatedly forced back, and only reached the opposite shore after floating down some 400 yards; and the operation of hauling the boat up each time against the ice to its original starting-point was very hard work. On the 9th we arrived at Saka Dzong, a small village, and found that Capt. Wood's party had reached there two days previously. We gave ourselves another day's halt here, as there was a good deal of surveying to be done in the neighbourhood.

Capt. Wood writes as follows, regarding his journey:—

"Leaving Lhatse on October 26th, we crossed the Tsangpo about half a mile below the town. A couple of boats had been collected by the Tibetans for ferrying across our kit and transport, but the process was very much shortened by the discovery of a ford about a quarter of a mile upstream, by which the ponies were able to cross. After keeping to the north bank for about 10 miles, we turned up a side nullah and camped at Sanggelung village; following this nullah next day for a short distance, we crossed by an easy pass into a country the drainage of which led into a succession of small lakes, whose surfaces were covered with geese and duck. On the largest of these, the Ngap-ring Tso, a tasam, or stage-house, is situated, which place we reached on the 27th. Hearing that no grain would be procurable until we reached Barkha, on the Mansarowar lake, we bought all we could procure, but even this would only give our ponies a couple of pounds daily. The next day we passed Ralung, the last place we saw cultivation. Every day now found us at a higher altitude, as we were marching more or less along the watershed between the Tsangpo and its large tributary, the Raga Tsangpo. The valley of this latter stream is narrow, running almost due east and west, parallel to and about 30 miles to the north of the main river. Into this distance is crammed a tangled mass of hills, whose crests average about 18,500 feet, with several peaks of about 22,000 feet covered with permanent snow. This part of our march was exceptionally unpleasant, as the wind on the hills never dropped by day below hurricane force, and, camping at elevations up to 16,100 feet, the change in temperature from the comparatively warm valley of the Tsangpo was most noticeable. The hills, clothed with a coarse grass on their lower slopes, but quite bare above 17,000 feet, were, as a rule, easy to climb; and from the summits lovely views of the Himalayas were obtained, Makalu and Everest, both standing out as great isolated peaks, being particularly imposing. The tasams, at which every four or five days we changed our yaks for fresh ones, were the only signs of habitations we met with, and these, as a rule, consisted of tents with a mud hut or two. The marches were all long and wearisome in their monotony, and, owing to the narrowness of the valley, Ram Singh and I, to carry on the survey, had to climb to the crests of the range every day, seldom getting into camp before sunset, and on one or two occasions not arriving before nine or ten at night. On November 5th we crossed the Ku La (16,700 feet), situated at the

headwaters of the Raga Tsangpo, and by a steep descent dropped into the valley of a small stream draining into the Tsangpo. At that night's camp we received letters from Capt. Ryder, saying that he would arrive at Saka Dzong on the 9th. Passing under the snowy range of Chour Dzong, whose peaks range up to 21,000 feet, we reached Saka Dzong on November 7th."

Saka Dzong. During our halt at Saka Dzong, Capt. Wood ascended a high peak to the north (19,300 feet), from which he had a fine view north up the valley of the Chata Tsangpo, a tributary of the main river.

Saka Dzong has only a dozen or so houses, very dirty, the neighbourhood (height 15,150 feet) being, like that of every Tibetan village, a dust and refuse heap. We left on November 11th, again in two parties. This time Lieut. Bailey accompanied me back to the river, while Capts. Rawling and Wood followed the main route. That day we forded the Charta Tsangpo, a fair-sized affluent of the main river, and, crossing some low hills, reached the Tsangpo on the 12th, crossing the same evening late, it being necessary to do so then, as from my previous experience I knew that the river would be nearly impassable in the morning from floating ice. We crossed in a small skin-boat, our animals fording higher up. For several days we marched upstream in a broad valley covered with low sand-dunes and stones, with a very small quantity of poor-looking grass, on which, however, kyang and gazelle seemed to thrive. The track followed by the Pandit Nain Singh, as he marched up from Nepal to Tradom in 1865, joined in on our left, but in these plains in Tibet it is difficult to find any signs of a path, as every caravan meanders over the plain without keeping to any defined track.

Tradom. We recrossed the river on the 16th; but now it was completely frozen over, and we crossed on the ice, the only thing necessary being to make a good track for the animals by throwing some earth down on the ice. That evening we arrived at Tradom, where we found the rest of the party had arrived on the 14th. The weather had been taking a turn for the worse; low temperatures at night we always had, cold winds in the day were the rule; but if the days were sunny a little walking would soon make us warm; when the days were cloudy, however, there was nothing to counteract the cold, and a march was a most miserable performance.

Captain Wood writes: "On leaving Saka Dzong, our party kept down the valley till we reached the Chata Tsangpo, which we found no difficulty in crossing. The stream was at that time some 100 feet in width, with a depth of 2 feet, flowing in one channel, having just left a very deep narrow valley to emerge into a plain of about 3 miles in width. Striking up a small side nullah, we followed it for 5 miles, and camped at the foot of the Lalung La. On this pass we first saw signs of *Ovis Ammon*, and from the information we received this appears to be the Eastern limit of their country along the road we had traversed. The road for the next three days—if it can be called a road—was the worst we met with, and consisted of large broken rocks set in deep sand; and to make us even more uncomfortable, the weather changed to snow, accompanied, as usual, by a howling gale of wind. Inhospitable as Tradom appeared to us when we first descried it, we hurried on, as fast

as our ponies would take us, to get within the shelter of its single stone house, where we might warm our frozen limbs over a yak-dung fire, and pity the remainder of our party who had still another two days to endure before they could hope to join us."

Tradom did not tempt us to halt; it is a desolate spot, with a small monastery on the hill above, inhabited by only three or four monks; but from the hills to the north we had a fine view of a snowy range reaching an elevation of 23,200 feet. We accordingly left the next day, and, marching across the plain all day, camped amongst the hills on the far side. This plain is full of small ponds lying among sand-dunes, and there was an unpleasant tributary or two to cross, the water frozen at the edges for 4 or 5 yards, then a drop of 3 feet into icy-cold water full of floating ice, and finally a scramble out on the other side on to ice again.

Source of the Tsangpo.

We now followed the river valley for a week or so, always in the same large plains, until we could see the watershed range ahead of us, from the valleys of which innumerable streams issue to form the Tsangpo, the largest coming from a snowy range to the south-west. After enjoying some days of bright sunshine, the weather again took a turn for the worse, and we crossed the Mayum La (16,900 feet) on November 26th with a foot or two of snow on the ground. We had now finished with the Tsangpo, having surveyed it from Shigatse to its source. Our next point of interest was to be the lake region ahead of us. The day after crossing the Mayum La we camped on the northern shore of the Gunchu Tso, a lake 11 miles long by 2 or 3 miles broad, with an area of 22 square miles, completely frozen over and having no outlet at all. Several *Ovis Hodgsonii* (*ammon*) had been shot before reaching the Mayum La; and we now came on large herds of Tibetan antelope, of which we each shot several, and could have shot many more if we had wished, as they were very tame.

Mansarowar Lake.

Crossing several low passes and generally undulating ground, we came in sight of the Mansarowar lake (Tibetan Tso Mobang) on November 30th. The lake is neither impressive nor beautiful, like, say, the Yamdrok Tso, passed on the way to Lhasa. It was not frozen over, except for 100 yards or so round the edge; the water was fresh, and our surveyor, Ram Singh, on account of its sanctity, bottled some and carried it back with him to his home in Dehra Dun. Skirting the lake, we rode across the low hills, which close in on the western side, to look for the outlet, which Moorcroft had not been able to find, which Strachey had found, and which Mr. Savage Landor had claimed to have proved did not exist. We struck the channel a mile below the outlet, a small stream only partly frozen over; this we followed up, and found that it did not flow from the lake, but from a hot spring, at which we found and shot some mallard. We then followed up the dry nullah to the lake, and proved that Strachey was, as was to be expected, quite correct. No water was flowing at this time of year, but the local Tibetans all agreed that for some months in each year there was a flow during the rainy season and the melting of the snows, *i.e.*, about from June to September. As a rise of about 2 feet in the level of the lake would cause water to flow down the channel, this

appears quite worthy of belief. The channel runs westward to another lake, the Rakas Tal (Tibetan Lagang Tso), about 3 miles distant.

That day, December 2nd, we reached a Tibetan stage-house, and next day had a long day's ride to try and discover an outlet for the second lake. This is very dissimilar to the Mansarowar in shape, and was entirely frozen over. The latter is about the same width, 12 miles, north and south as it is east and west, with an area of 110 square miles; the former is a long narrow lake running north and south, some 16 miles long by 3 or 4 miles wide, with an area of about 55 square miles. It is the sacred character of the Mansarowar lake rather than its size which has made it well known; its height above sea-level is 14,900 feet.

Source of the Sutlej.

We found an old stream-bed issuing from the Rakas Tal, but every Tibetan we asked told the same story—that no water ever flowed along it now, but that in days gone by, one man saying before the Sikh war, water did flow out of the lake and down this channel. We followed it down for some 6 miles along the plain, and could find none of the ordinary signs that water flowed down it until we reached some low hills; here evidently, from the lie of the sand, water flowed at some time of the year, and away from the lake. The lakes being now entirely disconnected at all times of the year from the Sutlej river, the sources of that river must lie in the hills on either side of the valley and west of the lake region.

The Kailas peak was very prominent on the hills to the north, snow-covered, 21,800 feet in height. The strata forming the mountain are horizontal, which gives it a peculiar appearance; from the side we saw it, the top was quite inaccessible. There are several monasteries on the path which pilgrims follow in circumambulating the mountain. A very fine snow-mass, culminating in a peak over 25,000 in height, Mémo or Gurla Mandhata, lies to the south of the Mansarowar lake. A low water-shed south-west of the lake leads to Purang or Takla Kot.

Gartok.

Keeping to the north side of the broad open valley in which the Sutlej flows, we arrived at another stage, Menzé or Missar, on December 5th. Here we divided, sending our heavy baggage down the valley with Ram Singh, as I wanted him to continue the survey of the Sutlej valley while we went into Gartok. We were pleasantly surprised to find the Jerko La, the pass on the Sutlej-Indus watershed, low and easy (16,200 feet), and without difficulty reached Gartok (15,100 feet) on the 9th. This is the summer residence, Garyarsa; the two Garpons, the joint governors of Western Tibet, were residing at Gargunsa, the winter residence, some 30 miles down the valley, but had come up to receive us.

We only halted one day at Gartok; in that time we had seen more than enough of it. We were unanimous in looking on it as one of the most dreary inhabited places we had struck in our journey. A long broad plain, absolutely bare, with a dozen wretched hovels in the middle, constitutes at this time of year what is in summer the chief trading centre of Western Tibet; but in summer traders are said to collect in large numbers, living in tents. The wind howled continuously round the hut we were in, and, the weather looking threatening, we were not anxious to stay a minute longer than was necessary for Capt. Rawling to settle up trade questions with the Garpons.

Having now accomplished the main object of our journey, it only remained for us to get back into India as soon as possible. Fortune had favoured us so far, but we had some high passes to cross. The first of these was the Ayi La, height 18,700 feet. Two marches took us to near the top of the pass, encountering a blizzard the second day. That evening we saw the only herd of wild yak we had come across in our journey. Crossing the pass next day was no easy matter; the ascent was gradual, but there were 2 feet of snow on the ground and a bitterly cold wind was blowing. It was with the utmost difficulty that, under some shelter from a rock, I took boiling-point observations, and with a sigh of relief hurried down the other side. One of our chief obstacles was surmounted. It began snowing on the pass that evening, so we had only just crossed in the nick of time. At Dunkar (14,100 feet), where we camped that night, we met cultivation for the first time, and it was a pleasant sensation to feel that we were gradually coming to the end of high altitudes. Down the Sutlej to Simla.

From here Capt. Rawling and Lieut. Bailey next day marched to Totling (Tibetan Tuling), on the Sutlej, where they met Ram Singh's party. Capt. Wood and I halted a day at Dunkar, and marched next day to Tibu, where the whole party was once more united. We were now in the most cut-up country I have ever seen; it must resemble the loess formation of China. The bottom of every nullah was some hundreds of feet below the general level of the valley, with their edges so cut and worn into fantastic shapes that it was difficult to believe that one was not looking on the ruins of old castles. There are also innumerable caves, in which the inhabitants live.

On December 16th, at Kyinipuk, we met Thakur Jai Chand, who had been sent up to be our trade agent at Gartok. He brought with him some very welcome newspapers. I must own we none of us envied him his job for the winter.

Each day's march now consisted of climbing up out of a deep nullah and down again into the next. We crossed the Shiring La (16,400 feet) on the 21st, in deep snow, with great difficulty, the descent on the western side being very bad going. Next day we camped at Tyak, on the Sutlej, which had been flowing on the left of our route only a few miles distant, but invisible to us owing to its being at the bottom of a deep gorge. On the 23rd we marched to Shipki, crossing the river on the ice, elevation 9,300 feet. On Christmas Eve we surmounted our last obstacle, the Shipki La on the frontier—a climb of 5,000 feet, mostly in snow, and a drop of 6,000 feet on the other side—and camped at Khab in British territory. From here we had eighteen marches into Simla, finding bungalows at every stage on and after December 28th, finally arriving at Simla on January 11th.

The area we surveyed with the plane-table comes to about 40,000 square miles. We surveyed the Tsangpo from Shigatse to its source; surveyed the Mansarowar lake region, and settled the doubtful points connected with it, which have been the subject of much discussion; we completed the survey of the Sutlej river from its source to where it enters British territory, and surveyed the source of the Gartok branch of the Indus. Survey Results.

The triangulation, which is still under computation, was invaluable to correcting the plane-table work and fixing many heights.

The cold we had to contend against was at times very severe; the lowest minimum we recorded was $-24°$ Fahr., but as the thermometer always registers its lowest on clear still nights it is not a good guide. It may be generally said that when the air was still the cold was quite endurable, and on sunny days, out of the wind, no climate could have been more pleasant. When, however, the wind blew, which, I am sorry to say, was generally the case, no clothing ever invented was sufficient to keep one warm. When a hurricane occurred on a cloudy day, our surveying was done with lightning rapidity, our great object being to hurry on to the friendly shelter afforded us by our tents; but the constant change of scenery, and the interest of our journey, did much to counteract the discomforts we met with.

My companions will agree with me that the success attending our journey was in the first place due to the friendly attitude of the Tibetans, induced by the cordial relations which Sir Frank Younghusband had established with the Lhasa Government. We were indeed glad to be able, by only two or three months' hard work on our part, to prove that the treaty signed at Lhasa was not merely a paper one, as might so easily have been the case, but that it inaugurated an era of truly friendly relations between ourselves and the Tibetans.

I am greatly indebted to my companions, Capt. Rawling and Lieut. Bailey, for the ready assistance and hard work they underwent in furthering the survey work, in which Capt. Wood and our native surveyor, Ram Singh, proved themselves sterling workers.

REVIEW.

THE LIFE OF GENERAL SIR ANDREW CLARKE.

By Col. R. H. Vetch, C.B.—(John Murray. 15s.).

Colonel Vetch has had a difficult task to perform. To compress within the limits of one volume, and that of a manageable size, the mass of interesting and valuable material which has been placed at his disposal, could have been no easy matter and he may be fairly congratulated on the manner in which he has accomplished his labours. "The Life of Sir Andrew Clarke" is one which may be studied with advantage by every officer of the Corps; in each chapter there is much that is of interest and in most there is something to be found of real value to us whether as soldiers, engineers, or administrators; indeed, if there is a fault to be found with what is otherwise an excellent biography, it is that Colonel Vetch, while giving us an admirable narrative of Sir Andrew's official duties and achievements, has tied himself down too much to these and has but little revealed Sir Andrew's personal qualities, and has made but few references to that wonderful magnetism which he so successfully exercised and to that gift of getting others to work heartily and willingly for him which he, like so many other really great men, so largely possessed.

The value of this book is greatly enhanced by the admirable "foreword" which Sir George Sydenham Clarke has supplied. As he so truly points out Sir Andrew's training had been of the most varied, and—for a military officer—of the most exceptional nature. "It was a kind of training which our Empire alone can provide for its sons and to the value of which Lord Cromer has recently paid a striking tribute."

To Mrs. Sueter our thanks are due for the excellent portraits so faithfully reproduced and for the trouble she has taken to enable the compiler to have all the correspondence at his command.

To the younger officers of the Corps we commend this book as well worth their study. It shews how a young R.E. subaltern, starting with no particular advantages and no powerful friends, was able by dint of his own faculties and exertions to obtain the "blue ribbon" of his profession, to reach some of the highest positions in the service of his country, and to leave a mark for good on every Department over which he presided.

Sir Andrew's public life falls naturally into four distinct phases—his early career in Australasia—the Directorship of Works at the Admiralty—his Governorship of the Straits Settlement and on the Council in India—and his tenure of the offices of C.S.M.E. and I.G.F.

Born at Southsea in 1824—the son of Colonel Clarke, R.E., formerly of the 46th Foot—Andrew Clarke passed into the "Shop" at sixteen. From the very first he gives evidence of having a careful mind and of

being "a first-class fighting man," for [unlike most cadets of that period we should imagine] he kept a diary, and in it we find a record of a fight with his old friend the late General Sir Michael Biddulph.

"8 March.—Biddulph impudent to me at drill. Kicked him.

11 March.—Biddulph made corporal.

14 March.—Biddulph challenged me for what occurred on Tuesday. Refused to fight on this score, but allowed him any other. Struck me on the stairs. We met in the Fourth Racket Court. First two rounds I got the best, but my wind did not do so well the other two. Hammer and tongs work. Separated. Biddulph apologized. Shook hands. Done up.

15 March.—Went into hospital with my face very much swollen. By the bye Buck was my second."

Clarke passed out first in his batch, took Sappers in June, 1844, and went from Woolwich for the customary course at Chatham. That he was not impressed with the Chatham curriculum of those days is evident from a letter written to his uncle afterwards, when he had served elsewhere (1850).

"I wish in the first instance, instead of going to Chatham, I had been sent abroad. When will the good folk in Pall Mall see the great advantages that would accrue from sending the young officers of Engineers abroad at once, and let them on their return serve for a year under the School of Instruction at Chatham? Chatham has ruined and spoilt ten times more good officers than it has taught their service and duty. It will be left to me when I am Adjutant-General or Inspector-General to create this change!"

His father meanwhile having been appointed to the Governorship of Western Australia, Clarke applied to be sent to Van Diemen's Land or Australia. He obtained his wish, was given command of a detachment of Sappers proceeding to Van Diemen's Land, and luckily for himself was ordered to embark in the same ship which took out the new Governor.

Sir William Denison, himself an old R.E., the brother of the Speaker of the House of Commons and of the Bishop of Salisbury, was doubtless soon attracted by Clarke's bright and winning manner and from that time interested himself in the young subaltern and helped to further him in his future career. "It was the luckiest day of my life," he writes to his uncle, Mr. William Hislop Clarke, "in which I first met my present chief and friend Sir William Denison. Had it not been for him I should have been but a mere drudging sub. of Engineers, still dreaming on and still castle-building; now I find myself, it is true, but at the lowest rungs of the ladder, but the ladder is there."

The ladder was there indeed and Clarke was not the man to miss his footing. Within three years Sir William Denison's private secretary died, and the appointment was offered to Clarke, at that moment road making with his sappers in New Zealand during the first Maori War.

His letters to his uncle written at this time form some of the most interesting parts of the biography. In them he describes his duties, his expeditions with his chief (either inspecting or hunting), his command of the Body Guard, his membership of the Legislative Council. His uncle advises him to lay by for a rainy day; but Clarke regrets that while the

means were somewhat increased, the expenditure was apparently unendable. "I hope however that by the time I return home I shall have a good balance with Cox. This is at present a mere pleasant dream. I I have often thought what a splendid effort it must have been on the part of my dearest father, subduing apparently that innate failing of all our characters—not knowing correctly the measure of our cloth for the coat we intended to wear."

Clarke was not long in gaining the respect of the Legislative Council and was beginning to be recognized as a power in the Colony; but he wanted a wider field for his energies, and this was not long in coming. The District of Port Phillip—recently separated from New South Wales and created a new Colony under the name of Victoria—wanted a Surveyor-General and Clarke was offered the post with a seat in the Council. Sir William Denison fully approved of his accepting, and in a letter which will be read with deep interest bade Andrew Clarke God-speed in his new career.

At the early age of 28 Clarke, still a subaltern in the Corps, now found himself at the head of a public Department; as a member of the Legislative Council of Victoria he was entrusted with all municipal legislation and as Surveyor-General had sole charge of all Public Lands. The five years (1853—1858) during which he held this appointment gave him an administrative training such as has fallen to the lot of few officers of the Corps.

Twelve years had passed (1858) since Clarke had left home; and the War Office now called on him either to elect to remain in civil employment or return to the Corps. He returned to England early in 1859 and for the next 5 years was employed on military duties; he was C.R.E. at Colchester and afterwards at Birmingham—he was disappointed in an offer of the A.D.C.-ship to Sir John Burgoyne—he acted as Agent-General for Victoria, and was sent as a special service officer to Cape Coast Castle where the Ashantis were giving trouble, and he published a report on the Gold Coast which was the best description available at the time of the subsequent Ashanti War.

To Australia Clarke owed many things and perhaps not second even to his early connection with Sir William Denison, was his lifelong friendship with Mr. Childers. The latter, three years the younger of the two, had arrived in Melbourne two years before Clarke; they had been called together to take part in the first Government of the colony and had together assisted to draft the bill for its new constitution. They early learned to respect each other and to appreciate each other's remarkable abilities. When their work was done in Australia they again met in the old country, where their early acquaintance was destined to be on two occasions of great advantage to the country. Mr. Childers, who had now been four years in Parliament, became Civil Lord of the Admiralty under the Duke of Somerset in the spring of 1864 and in the following August was able to suggest Clarke's name for the Office of Director of Works at the Admiralty in the place of Colonel Greene, C.B., an old R.E., who had just vacated it. No better appointment could have been made, and it was fortunate for the service that at so opportune a

moment his abilities were recognised. Had it not been for their collaboration in the early Australian Government, it is unlikely that this would have happened.

For the next nine years (1864 to 1873) Clarke's work was intimately connected with the welfare of the Navy and it is doubtless due to this fact that appreciation of our Naval needs and sympathy with the sailor characterized in so marked a degree his despatches and minutes from this time onward. He came to Spring Gardens at a critical moment; the old wooden fleet was giving place to the ironclad squadron, new dock accommodation was urgently called for, large extensions of existing yards were essential, and the Government of the day was called to lay out many millions to carry through these works. In the Director of Works technical knowledge was undoubtedly needed but it was by no means the only qualification. To convince a reluctant Chancellor of the Exchequer (at that time at daggers drawn with his own Prime Minister on questions of economy) of the necessity of this or that Naval expenditure was no easy matter. Lord Palmerston and the Duke of Somerset generally took one line, Mr. Gladstone and Mr. Childers took another. Diplomacy, good temper, and patience were essential, and Clarke proved himself indispensable. To him we are indebted for the initiation of the great dockyard extensions at Portsmouth, Chatham and Malta, he was responsible for the success of the Bermuda floating dock, he urged on the completion of Portland breakwater, and by his personal efforts he overcame Lord Palmerston's objections to spending money on the extension of Dover Harbour.

It is in dealing with this portion of his career that Colonel Vetch has brought to light, we believe for the first time, the fact that Clarke was the first to point out the advantages of the purchase of the Suez Canal shares. The French shareholders were willing to be bought out and at Clarke's instance Mr. Childers brought the matter before the Cabinet and supported it strongly; but without success. "I am sorry," he wrote, "and have done my best. Granville was with me. Cardwell and Lowe the other way. Gladstone at first my way."

In May, 1872, Lord Kimberley offered Clarke the Government of the Straits Settlements and for the next eight years he was once more abroad. We have no hesitation in considering Clarke's work while at Singapore to be the most important service he rendered to his country, and Colonel Vetch has been well advised in treating these services in full detail. How he cemented friendship with Siam, composed the faction quarrels of the Chiefs of the scattered Malay States, how he put down piracy and persuaded the Chinese headmen to surrender their junks and to destroy their stockades, and finally how he did not hesitate to appoint Residents to the Native States on his own responsibility, these the reader will find carefully and accurately recorded in Chapters VI. to VIII. Sir Andrew was only 18 months at Singapore but they were months of "strenuous life." In Colonel Vetch's words "He is honoured with a place next to Sir Stamford Raffles in public estimation as the author of progress in the Malay peninsula. . . . In 1874 the revenue of the two native States, Perak and Selangor, was 100,000 dollars which went into the pockets of native

Chiefs for their own selfish indulgence. In 1900 the revenue of these States had risen to 13,500,000 dollars and paid for an administration which promoted the peace and prosperity of the country."

We have always considered it was unfortunate for the public service that Sir Andrew was persuaded to exchange the Governorship of the Straits for a seat in the Council of the Governor-General of India. He left Singapore when his task was half accomplished, and handed over his government to a successor who did not sympathize with his views and reversed his policy. Colonel Vetch tells the story of this "new departure," and the subsequent outbreak which culminated in the Perak Campaign.

Whatever the precise reasons may have been, Sir Andrew accepted Lord Salisbury's no doubt flattering offer of the newly created office of Member of Council for Public Works in India; but the change proved of doubtful advantage: he went to India during Lord Northbrook's *régime* "anticipating" as Colonel Vetch writes "an expanding policy in Public Works which nobody could have directed better than himself. Instead, depreciation of silver, apprehension of famine, and frontier wars forced upon the Government of India a policy of severe retrenchment and economy during the whole term of his office." He found himself continually in opposition to Lord Lytton, who followed Lord Northbrook, and driven to play the part of Cassandra. Arriving in India in June, 1875, he at once perceived that the Governor-General's policy would inevitably land us in a war with Afghanistan; [to the writer of these lines he wrote during that year advising him to apply for employment in India adding "We are certain to have a war with the Amir of Cabul."] Again and again he urged Lord Lytton to face the facts, and, by the construction of lines of telegraph and railway while there was yet leisure, to prepare for a contingency which the policy of the Government was rendering a certainty. But Lord Lytton was as deaf to his entreaties in 1876 as Lord Hartington was to be in 1884 and the disastrous waste of millions on the transport in Afghanistan was only equalled by the money thrown away in attempting to rescue Gordon by the Nile expedition. Had Sir Andrew's advice been accepted and had the railway been begun in good time to the mouth of the Bolan Pass in 1877, and from Suakin to Berber in 1883, how different might have been the result!

Trojaque nunc staret, Priamique arx alta maneret.

The war in Afghanistan was essentially an Engineer's war—roads, railways, telegraphs, all were urgently needed: the demands on the R.E. in India during 1878–9 were enormous but Sir Andrew was equal to the occasion; he took care that the Corps was well represented, and co-operated with General Lumsden and General Roberts in selecting the fittest officers for the various commands. "You will of course," wrote Major-General Roberts, "nominate the R.E. officers for the several columns. The Commanding Royal Engineer I would prefer is Colonel Perkins . . . of all the junior officers I would prefer Captain Pierson."

Perhaps nothing in this biography shews more clearly how much in advance of his time Sir Andrew was, than his letter to Lord Rowton

(then Mr. Montagu Corry) in which he unfolds his scheme for the creation (on the occasion of the first Imperial assemblage at Delhi) of a great Imperial Indian Senate.

"Take advantage of the present moment" (he is writing from Simla in 1876) "and give now to the princes and people of this country some recognition that they have a political and national existence. If done now you will consolidate and strengthen the English power in this peninsula, and call a true empire into life and vigour. . . . Extend to the nationalities of India the manifest responsibility of having a share in directing its destiny and you surround the Imperial crown with a triple line of defence."

That such an idea would meet with a sympathetic reception from Lord Beaconsfield, for whose eye it was of course written, was not unlikely; but we are not given Mr. Corry's reply. Lord Lytton we are told was not absolutely averse to the idea, but he shrewdly observed that if the people of India got their House of Lords they would undoubtedly want their House of Commons.

Sir Andrew returned home from India in June, 1880, after an absence of 7 years; he had initiated a great policy at Singapore and had borne a large share in the Government of India during a critical period of famine and war, but to the War Office authorities he was of course only known officially as a regimental officer awaiting employment, and although he had been Governor of the Straits and Member of Council in India he found himself nominated for the post of C.R.E. at Woolwich; but a vacancy occurring in the office of Commandant of the S.M.E. he was selected to fill it. Then came the "bolt from the blue." The appointment of Inspector-General of Fortifications became unexpectedly vacant in the following year, and was in the gift of the Secretary for War. Mr. Childers had once more, as on a former occasion, the good fortune to be able to select one of the candidates for the post from his own knowledge and experience of him. Clarke was not the senior colonel of those who had reasonable claims to the office; his fitness for it was undoubted, but there were such heartburnings as naturally occur when an unexpected promotion is made. "The appointment," in Sir George Clarke's words, "was sharply criticized," but it was more than justified by the result, and the efficiency of the office of the I.G.F. was strengthened in no ordinary degree by the boldness of the appointment.

Colonel Vetch has done full justice to Sir Andrew's career both as Commandant of the S.M.E. and as I.G.F. To officers of the Corps the chapters (X., XI. and XII.) which deal with this portion of his life will probably be read with greater interest than any others. This was the era of great developments; the extension of the Submarine Mining, the adoption of the Brennan torpedo, the entire revision of the imperial fortresses at home and abroad, and the protection of the mercantile ports, on all these points the Government of the day looked to Sir Andrew for advice and guidance; and they did not look in vain. His views were always clear and distinct. Whether he was reviewing the recommendations of the Royal Commission, or combating what he considered the mistaken opinions of a colleague at the War Office his advice was

unmistakable and his minutes terse and telling: he was a progressive thinker and a fearless fighter: and no respecter of persons, whether they were Secretary of State or Commander-in-Chief.

Space will not allow of dwelling on Sir Andrew's latter years. He continued to represent the Colony of Victoria till the time of his death, but this work was only a part of his daily engagement; his activity to the last was astonishing. As his old friend Sir Algernon Borthwick wrote "We have worn well in the thirty years (since the days of the 'Owl' in '65) and are all young at heart and glad of each other's successes. Do you remember how we all said we should get on?" Throughout his long official career Sir Andrew had the knack or good fortune to be at hand at the proper moment: he was one of those who always "fall on their feet"; he recognized his opportunities and he did not let them slip. He joined the Government of Victoria at the very moment of the Gold discoveries and the grant of self-government; he went to the Admiralty at the instant when enormous works were being considered in consequence of the development of the ironclad fleet; he was appointed Governor at Singapore in the year Disraeli was calling attention to the Straits of Malacca which were then in a ferment; he was in India when the Afghan imbroglio made enormous demands on the R.E. resources, and finally became I.G.F. when the outcry was raised for more defences for our coaling stations and when great developments in fortification were projected.

"Sir Andrew," states Colonel Vetch in his final summing up, "made many friends and the friends that he made stuck to him through life, and he to them. . . . Those who knew the man, and differed from him condoned the extreme views he held on some points, because they were so eminently characteristic of him; and 'Andy Clarke' as he was called by his intimates, would not have been 'Andy Clarke' had not the vivacious spirit that displayed itself in a stimulating treatment of even ordinary subjects sometimes rushed into excess. A genial manner and a kind heart always ready to serve a friend were attractions that few could resist. As a public man he was an able and hard-working servant of the State."

Most readers of the book will, we think, find the last sentence hardly strong enough. Abilities they were of no ordinary kind, both heightened and deepened by a prescience which was rarely at fault even if it made his schemes seem to many to be the dreams of a visionary; his was that powerful characteristic of always being a little in front of the time, instead of lagging behind—a characteristic which, while it nearly always invites criticism, in the long run is usually appreciated for its unselfishness and justified by its results. To quote the words written of him by Mr. Chamberlain "he (Sir Andrew Clarke) had the great satisfaction of seeing his principles generally accepted, and he must have felt that he had contributed to their success. . . . This is, after all, the reward for which all honourable and conscientious public men most earnestly strive."

SPENCER CHILDERS.

NOTICES OF MAGAZINES.

Engineering Record.

October 4th, 1905.

Reinforced Concrete Retaining Wall.—The design of the above, at the Baden Reservoir of the St. Louis Waterworks, is interesting, being of a similar style of work to numerous bridge abutments which have been built on the Wabash Railroad.

The wall proper is 24′ high, base to coping, tapering in section from 1′ thick at top to 2½′ at the point where it begins to splay into the foot. (The angle is filled up, and there is some cross reinforcement running through the foot of the wall at about 45° to the vertical). The buttresses are 15′ 9″ apart at centres and 2′ thick. (Actually these are not buttresses, but connecting members between the face wall and the foot). The foot is 15′ wide and 18″ thick. Coping is 39″ wide and 1′ thick.

Reinforcement consists of a grille of ¾″ to 1″ corrugated bars; in the wall proper the vertical series, which are on the puddle or tension side only, are spaced 1′ apart, and the horizontal series (on both sides) are spaced at 10″.

The footing contains a complete grillage one-third of the thickness through from the bottom. The buttresses or stiffeners contain a vertical series near the outer edge only.

The design is exceedingly economical in material as compared with an ordinary massive retaining wall; and seeing that this nature of design, where the weight of the mass retained can be brought on the flat foot to balance the overturning moment, is very advantageous, it seems that such walls are bound to be extensively used. They should be particularly suitable for defence works.

C. E. Vickers.

Nature.

November, 1905.

Survey of the Simplon Tunnel (*November, p.* 30).—Before the work of boring could be begun, three elements had to be determined with an accuracy in each case which must be greater in proportion to the difficulties of construction. These are the direction, the length, and the altitude above sea level. When the places of entrance and exit of the tunnel had been marked, the determination of these three elements began. That of the level is the least difficult, for by the aid of accurate instruments, it is possible to derive the difference in altitude of two stations 50 kilomètres apart with no greater error than 3 c.m. Several series of levels were taken, the mean showing a discrepancy of only 2 c.m., the

actual difference of level between the two ends being 52·439 mètres. The second element, that of the length of the tunnel, was derived from triangulation; in this great accuracy was not required; the probable error was ±0·7 mètre, the actual length being 19,728·71 mètres.

The third element, that of direction, at all times presents some difficulty, but in the case of mountains, when local attraction enters as a disturbing factor, the problem requires very delicate treatment. In a tunnel 20 kilomètres long, an error in direction of one minute, which is the usual limit of accuracy, would produce an error of 6 mètres, and the tenth of such an error would be too great. Eleven well-defined cylindrical signal towers of brick were erected about 8 feet high, of which the axis was an iron tube. The theodolite was placed centrally over the middle of the iron tube, thus securing a solid support for the instrument and permitting accurate observation of the other stations. With the care exercised, the sum of the angles of any triangle ought to have differed from 180° by the known amount of the spherical excess; but the actual discrepancies were much larger, varying from 4 to 8½ seconds; these deviations were evidently due to the attractive force of the mountain, which sensibly displaced the direction of the plumb line. This deviation at the north end was found to be 14″, at Rosswald 24″, and at the south end 6″.

Assuming these deviations from the vertical to arise from the attraction of the mountain mass, it was found possible to reduce the closing errors of the triangles very materially, so that the direction of the tunnel could be fixed with a probable error of only ±0″·7. This turned out most satisfactorily; the wall of the north tunnel was absolutely continuous with the wall of the south tunnel, though the observations had been impeded by curious refractive effects akin to those seen in a "mirage." These disturbing effects were most noticeable when observing towards the north end of the tunnel, where the difference of temperature between the internal and external atmosphere was greatest.

The meeting of the galleries with such accuracy is chiefly due to Dr. Rosenmund, of Zurich.

MARTIAN METEOROLOGY (*p.* 38).—A number of photographs taken with the 13-inch Boyden telescope at Cambridge (Mass.) in 1888, and again in 1890 with the same instrument at Mt. Wilson, California, show sufficient variation, due to meteorological changes, to prove the existence of an effective atmospherical circulation of moisture on Mars. On two occasions the height of the clouds above the Martian surface was measured, giving about 15 miles as the result; and Professor Pickering suggests that the existence or non-existence of such clouds in the equatorial regions may account for the discrepancies noted between various estimations of the amount of the polar flattening and also for the observed transfer of precipitation, during the Martian year, from pole to pole. On May 19th, 1905, the north polar white (ice) patch was first observed 126 days after the summer solstice; in 1903 the first frost effects were observed 128 days after the solstice.

W. E. WARRAND.

RECENT PUBLICATIONS.

A Study of the Russo-Japanese War, by 'Chasseur.' Reprinted from "Blackwood's Magazine." (8 × 5. 6s. Blackwood).

The Siege and Fall of Port Arthur, by W. R. Smith. (10s. 6d. Nash).

A Staff Officer's Scrap Book during the Russo-Japanese War, by Sir Ian Hamilton, K.C.B. (9 × 6. 18s. Arnold).

Port Arthur als Festung und Kriegshafen. Eine Studie nach Aufsätzen des *Voyennii Sbornik*, von Thilo v. Trotha. (1 mk. Schröder, Berlin).

Traindienst bei der Armee im Felde, von Fleck v. Falkhausen, Hauptmann im Generalstabskorps. (10 mks. Seidel & Sohn, Vienna).

A Military Geography of the Balkan Peninsula, by L. W. Lyde and Lieut.-Colonel A. F. Mockler-Ferryman. (7½ × 5. A. & C. Black).

The Hearseys. Five generations of an Anglo-Indian family, by Colonel Hugh Pearse, D.S.O. (9 × 6. 15s. Blackwood).

The Military Life of H.R.H., Duke of Cambridge, by Colonel Willoughby Verner, assisted by Capt. E. D. Parker. 2 vols. (9 × 6. 36s. Murray).

A History of Architectural Development, by F. M. Simpson, Professor of Architecture, University College, London. Vol. I. (2 vols. to follow). (9½ × 6. 12s. 6d. Longmans).

The Removal and Disposal of Town Refuse, with special supplement on Refuse Destructors and Power Production, by W. H. Maxwell, Assoc. M. Inst. C.E. (15s. Sanitary Publishing Company).

Mechanics of Air Machinery, by Dr. J. Weisbach and Professor G. Herrmann, translated by A. Trowbridge. (9 × 6. 18s. Crosby, Lockwood).

Telegraphy. A detailed exposition of the Telegraph System of the British Post Office, by T. E. Herbert, A.M. Inst. C.E., Engineer, P.O. Telegraphs. (7½ × 5. 6s. 6d. Whittaker & Co.).

The Anglo-Egyptian Sudan. A compendium prepared by officers of the Sudan Government. Edited by Lieut.-Colonel Count Gleichen, C.V.O., C.M.G., D.S.O. 2 vols. (12 × 10. 17s. 6d. Wyman & Sons).

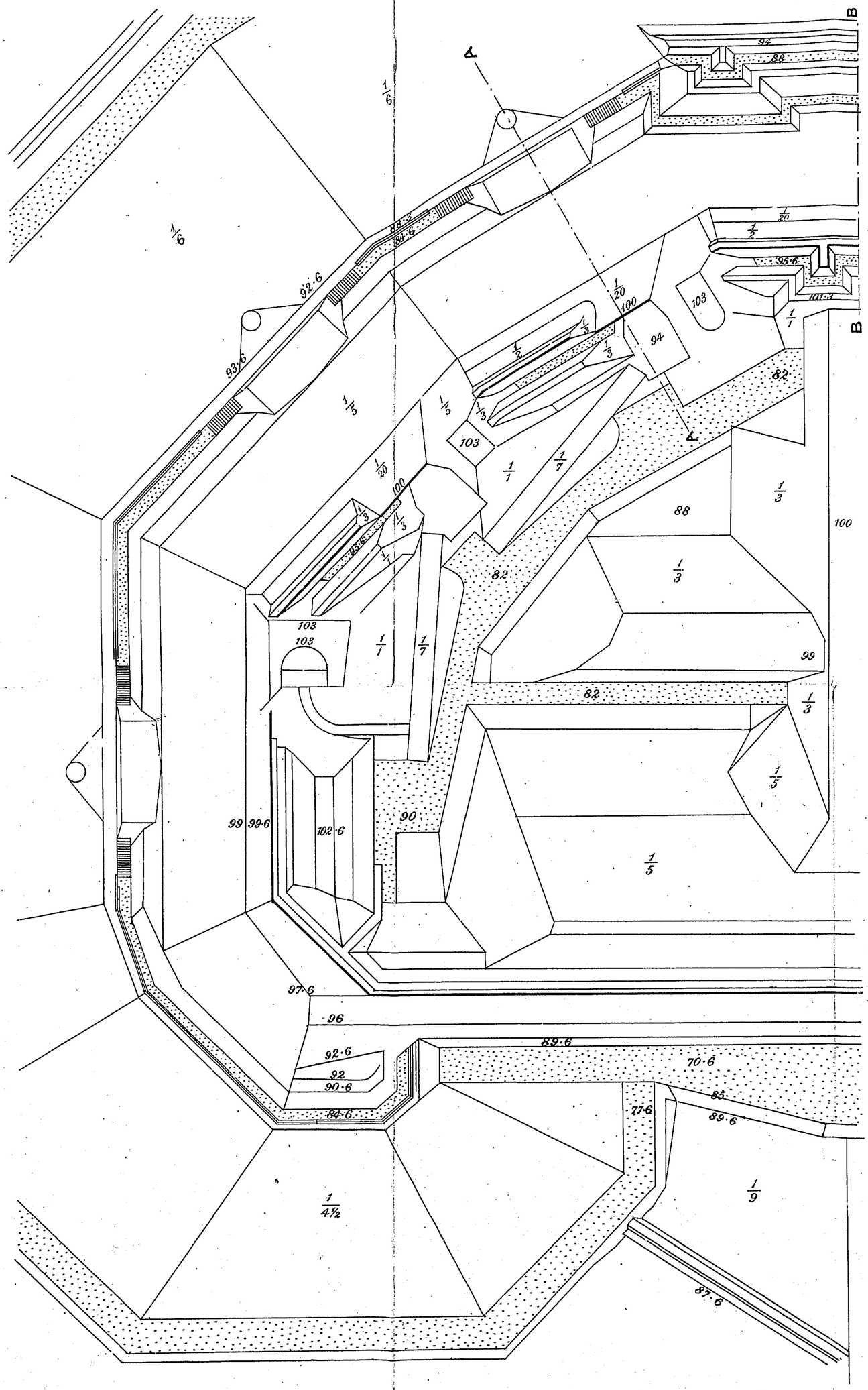
The Source of the Blue Nile, by A. J. Hayes. (8½ × 5½. 10s. 6d. Smith, Elder).

A Tropical Dependency. An outline of the Ancient History of the Western Soudan, with an account of the Modern Settlement of Northern Nigeria, by Flora L. Shaw (Lady Lugard). (10 × 7. 18s. Nisbet).

British East Africa; Past, Present, and Future, by Lord Hindlip. (8 × 5. 3s. 6d. Unwin).

Fig. 3.

Scale 1 inch = 40 feet



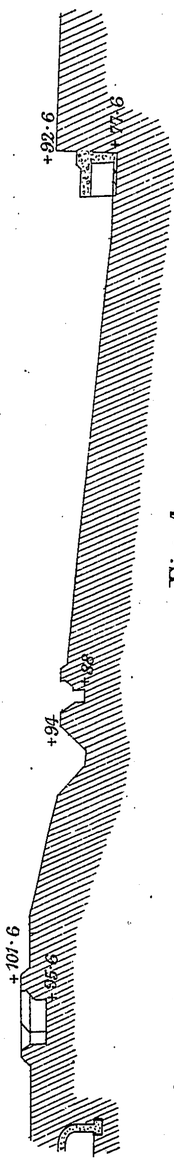


Fig. 4.
SECTION B.B. ON FIG. 3.
Scale 40'=1"

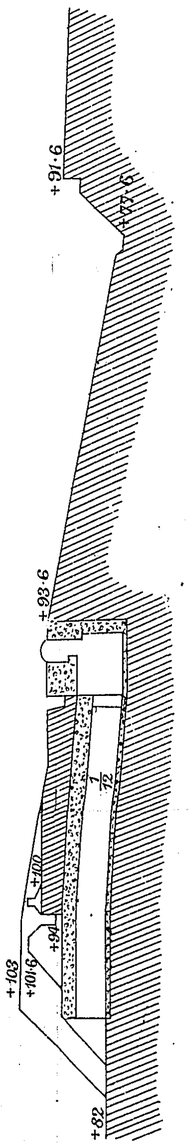


Fig. 5.
SECTION A.A. ON FIG. 3.
Scale 40'=1"

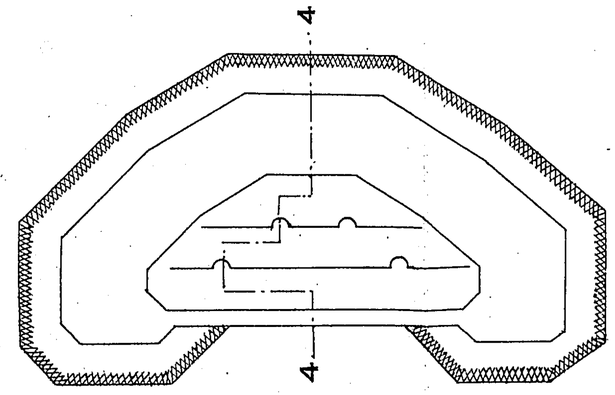


Fig. 6.
SKETCH PLAN OF IDEAL FORT
Scale 200'=1"

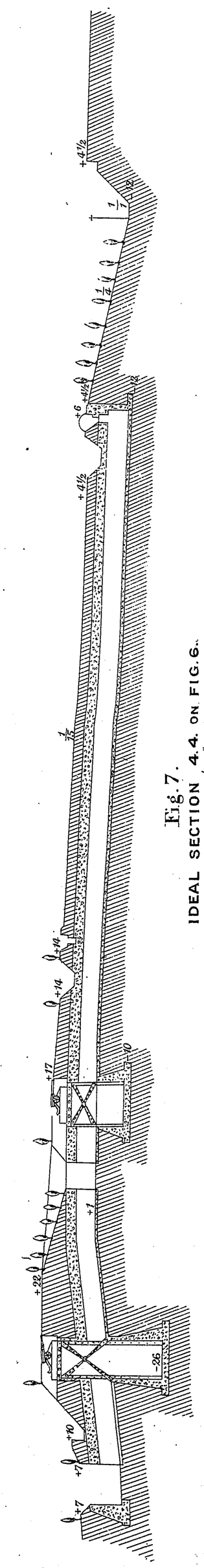


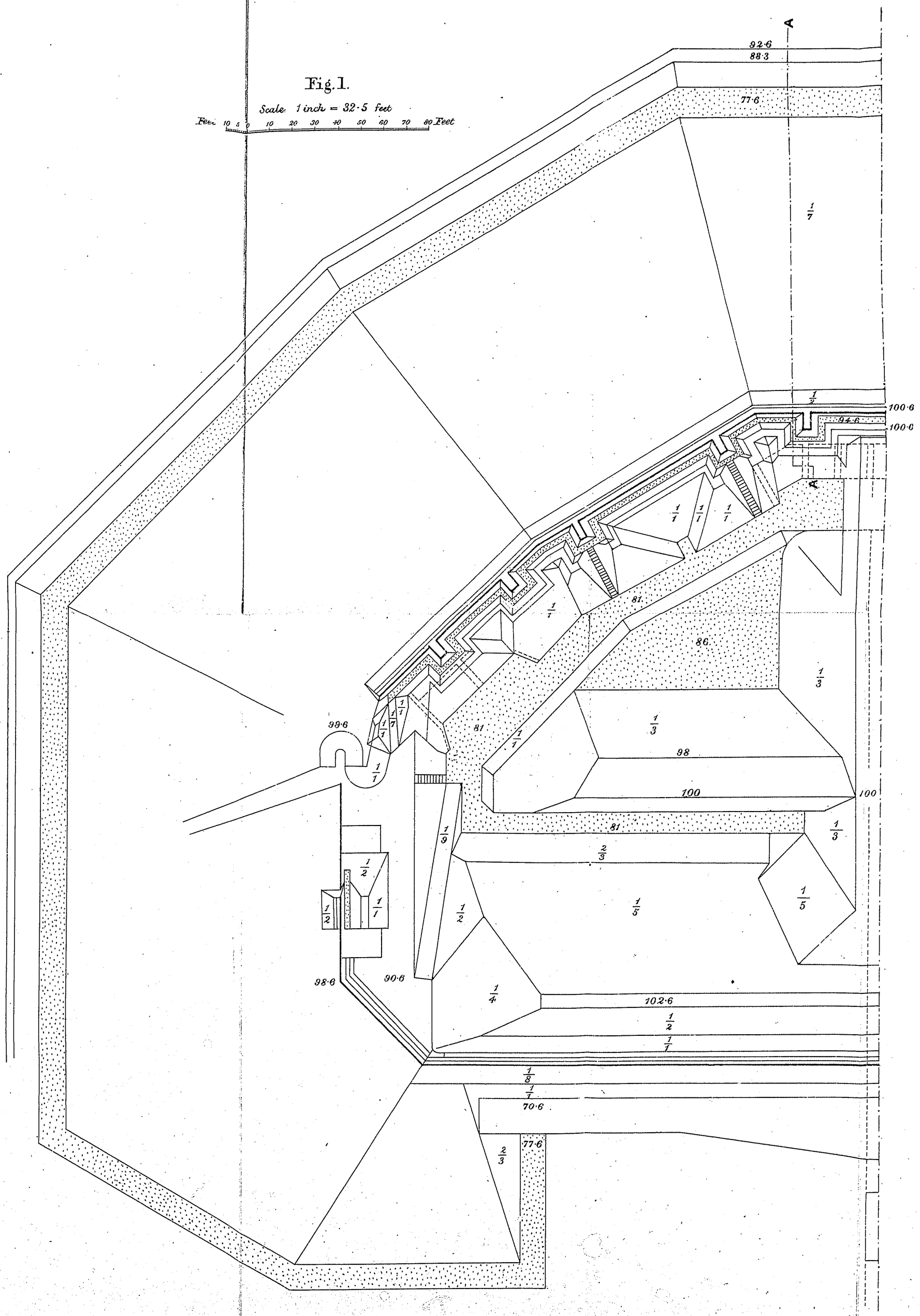
Fig. 7.
IDEAL SECTION 4.4. ON FIG. 6.
Scale 40'=1"

ARE OUR IDEAS ON PERMANENT FORTIFICATION UP TO DATE.

Fig. 1.

Scale 1 inch = 32·5 feet

Feet 10 5 0 10 20 30 40 50 60 70 80 Feet



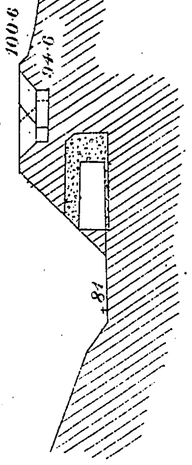


Fig. 2.

SECTION A.A. ON FIG. 1.

Scale 32½" = 1'

TIBET

Map showing Explorations
by
MAJOR C.H.D.RYDER, R.E., D.S.O.
and
CAPTAINS H.WOOD, R.E. & H.M.COWIE, R.E.
OF THE
TIBET FRONTIER COMMISSION.
1904.

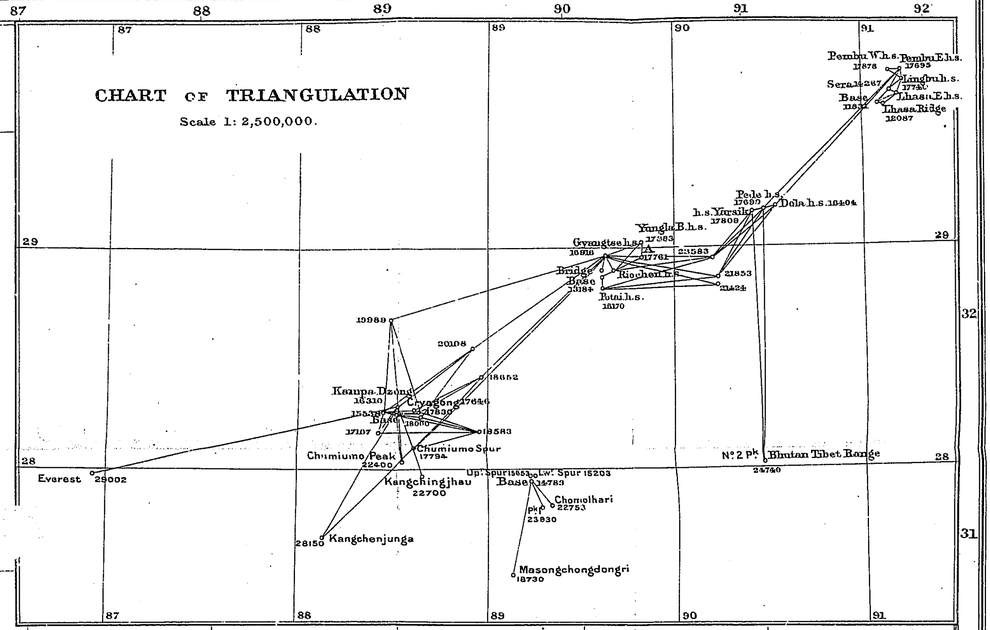
Reduced from the Sheets of the Survey of India.

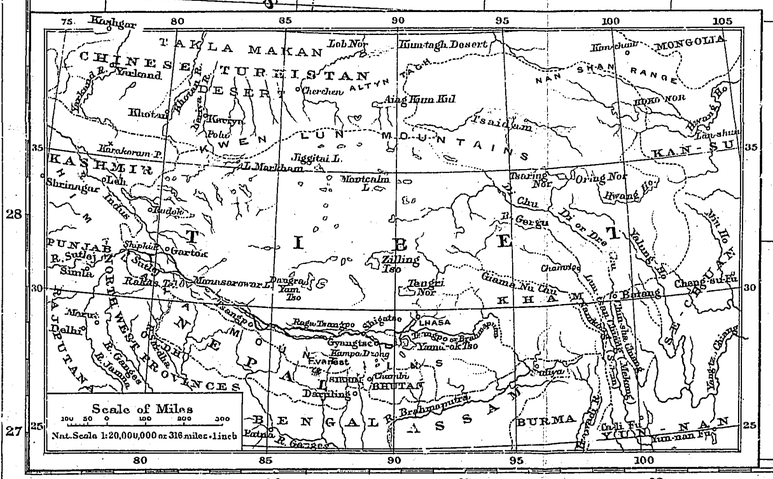
Scale of Miles.
20 10 0 20 40 60 80 100
Nat. Scale 1: 2,500,000 or 39·45 miles = 1 inch.

Route of Expedition ———
Heights in feet.

CHART OF TRIANGULATION

Scale 1: 2,500,000.





Secant Conical Projection.

CALIFORNIA.

A SPLENDID INVESTMENT, WITH AN IDEAL EXISTENCE, IN WORLD-FAMED RIVERSIDE, CALIFORNIA.

AN opportunity occurs of SECURING a few well-matured WASHINGTON NAVEL (or Seedless) ORANGE GROVES AT RIVERSIDE, CALIFORNIA, at a price which will yield about 15 per cent. on the capital invested. No expense has been spared by a syndicate of English gentlemen since 1898 in developing this estate, which covers some 600—700 acres. If desired, arrangements can be made for the management and maintenance of orchards, at a reasonable rate, as also for the packing and selling of the crops in the best markets. A CAPITAL OF ABOUT £500 IS NECESSARY. Arrangements can be made for a cash deposit of one half of the actual purchase price, the balance remaining on mortgage for a period of years to approved purchasers. References can be given to gentlemen of the highest standing in England. RETIRED NAVAL AND MILITARY OFFICERS COULD NOT CHOOSE A MORE IDEAL SPOT THAN RIVERSIDE, CALIFORNIA, IN WHICH TO SETTLE DOWN. The climate is unexcelled; the society is good. There are three excellent social clubs, also clubs for polo, golf, and lawn tennis. FIRST-RATE WILD DUCK, QUAIL, DOVE, AND OTHER SHOOTING. Polo ponies are cheap, as is also their feed. Living expenses and house rent are very reasonable. As every investigation of this property is courted, the Press are cordially invited to interview us.—For further particulars write to, or call on, The California Real Estate Agency and Inquiry Bureau, 21, Copthall Avenue, London, E.C.