R·E

## ERRATA FOR R.E. AIDE MÉMOIRE FROM DATE OF PUBLICATION TO THE END OF 1880.

Index, "Well, American tube," reference should be "215, 216," *instead of* "115, 116"

Par. 9. For "$s = (2b - n + 1)\frac{nl}{2}$" *read* "$s = (2l + n - 1)\frac{nb}{2}$"

Par. 105, third line, *for* "12 sacks of 4 bushels each" *read* "12 sacks of 3 bushels each"

Par. 150. *Take out* "$-$" from beginning of last equation.

Par. 153c., headings of 4th and 5th columns, *for* "$\frac{l}{d} <$" *read* "$\frac{l}{d} >$"

Par. 154, 2nd line, *for* "Shields" *read* "Sheilds"

Par. 162, Fig. 81, *for* "$y_0$" on line OO, *read* "$y_1$"

Par. 162, eighth line from bottom *for* "$\frac{f_0}{y_0}$" *read* "$\frac{f_0 y}{y_0}$"

Par. 165b., Example, first line, *after* "18′ span" *read* "6″ deep"; second line, *for* "1′" *read* "6″ deep"

Par. 171, last line but one, *for* "$\sqrt{\frac{1}{3} a_2 (a_2 - 2a_1)}$" *read* "$\sqrt{\frac{1}{3} a_2 (a_2 + 2a_1)}$"

Par. 180 *for* "$Q = m A \sqrt{2g}h$" *read* "$Q = m A \sqrt{2gh}$"

Par. 180, last line but three, *for* "$(1 + 152 \frac{n}{p})$" *read* "$(1 + 0{\cdot}152 \frac{n}{p})$"

Par. 182. In the equation, *take out* the bracket $\{$

Par. 183, last line but two, *for* "$2 \times 228 \times \frac{\cdot 548}{\cdot 625} = 130$ seconds"

*read* "$\frac{1}{2} \times 228 \times \frac{\cdot 625}{\cdot 548} = 130$ seconds"

Par. 199, fourth line, *for* "par. 598" *read* "par. 198"

Par. 201, page 123, 10th line, and 2nd column of table, *for* $\propto$ *read* $\alpha$

Par. 243, sixth line *put* "$e$" before "$= \frac{V\sqrt{G}}{\sqrt[3]{l}}$"

Par. 250, page 156, second line above Fig. 124, *for* "circumference," *read* "centre"

Par. 250, page 156, last line but one above table

*for* "$ABF = (1718{\cdot}837 \frac{a}{r})$" *read* "$ABF = 4(1718{\cdot}873 \frac{a}{r})$"

and *read* 1718·873 *not* 1718·837 throughout.

Par. 250, page 156, last line above table, *for* "may be checked by par. 252," *read* "may be checked by concluding example in par 250"

Par. 250, page 157, second line of Note, *for* "¼ chain chords" *read* "½ chain chords"

Par. 253, page 160, 20th line from bottom,

*for* "30 (length of log in feet) = 369"
*read* "18 (No. of cub. feet in log) = 221·4"

Par. 312, *for* "$\frac{W V^2}{2g - 2240}$" *read* "$\frac{W V^2}{2g \times 2240}$"

Par. 341, page 212, 13th line from bottom, *omit* "gunpowder"

Par. 449. The task for one hour *should be* "5′ × 5′ × 1′ 6″," and for two hours, "5′ × 8′ × 1′ 6″" The breadth of "$b$" in the figure should be altered to "2′ 6″," and that of "$c$" to "3′"

Par. 547. In table 2, column "May," *for* "25" *read* "24"

Par. 547, last line, *for* "in June a Saturday," *read* "June is a Saturday"

Par. 549, second line, *for* "par. 1246," *read* "par. 546"

Par. 600, page 379, eighth line from bottom, *take out* "." after "minus"

Par. 600, page 380, fourth line, *after* "P S," *read* "$-$"

## NOTE BY EDITOR.

Major Parnell has drawn my attention to the fact that the Table of Penetrations given at the top of page 199, *R.E. Aide Mémoire*, which was taken from the report of the Committee of 1869, does not give a correct idea of the relative resistance to penetration of concrete and other materials, as deduced from more recent experiments. He forwards two Tables :—

No. I containing extracts from the "Second Report of the Special Committee on Siege Batteries," dated 17th March, 1877, in which the relative penetrations with brickwork and concrete is given.

The results, however, in this table are complicated by the fact that the charges, ranges, and natures of shell differed in the different experiments. Major Parnell has accordingly furnished a second table, in which he has taken these factors at the same value, and calculated the penetrations under the altered conditions.

A. C COOKE,

COLONEL, R.E.

TABLE I.

| Experiments. | Material of Target. | Nature of Ordnance. | Charge | Nature of Shell. | Weight of Shell. | Range. | Penetration. | Further Results. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | lbs. | | lbs. | yards | | | |
| *a* | Brickwork; ("good mortar, soft bricks.") | 64 pr. R.M.L. | 12 | Palliser Chilled. | 90 | 1040 | 8ft. | After piercing this wall, shell proceeded onwards "with considerable velocity." | Part of a Martello Tower; masonry of "fairly good quality." |
| *b* | Portland cement concrete; ("fair quality," 1 part, cement 3 parts sand, 5 parts shingle.) | do. | 10 | do. | do. | 103 | 4ft. 8ins. | Shell loaded, but not fused, and did not explode. | Against an epaulment prepared for purpose. |
| *c* | Ditto. | do. | do. | Common. | 64 | do. | 2ft. 6ins. | Shell as above, burst on impact. | Against same epaulment. |
| *d* | Ditto (not so good quality; 1 part cement 4 parts sand, 6 parts small shingle.) | do. | 12 | do | do. | 1070 | 4ft. | Shell burst after full penetration and broke up concrete to width of 10 feet. | Against another epaulment. |

*Extract from Remarks of Committee.*

"Concrete shows a decided superiority over brickwork in its power of resisting the penetration of projectiles. . . . . . . It is very necessary to chose a material for concrete which shall give a good surface for the adhesion of the cement, shingle not being suitable in this respect. . . . . . . The proportion of cement should not be less than 1 in 8. . . . . . . In order to penetrate good concrete, a projectile much stronger than the service 64-pr. common shell is required."

TABLE II.

Experiments in Table I. corrected to give approximate Penetrations with an uniform charge, weight of Shell, and Range, of 10 lbs., 90 lbs., and 100 yards respectively.

| Experiments. | Material of Target. | Penetration. | Remarks. |
|---|---|---|---|
| *a.* | Fair Brickwork. | 10 feet. | Allowance has been made for residual velocity of shell after piercing wall. |
| *b & c.* | Fair Portland Cement Concrete. | 4 ft. 8 ins. | |
| *d.* | Poor Portland Cement Concrete. | 7 ft. 6 ins. | |

# PROFESSIONAL PAPERS

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EDITED BY

MAJOR R. H. VETCH., R.E.

# ROYAL ENGINEER INSTITUTE

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# PREFACE.

The IVth Volume of the New Series of *Professional Papers*, issued in two parts (Nos. 12 and 13) as *Occasional Papers* for the year 1880, will be found to contain interesting matter in connection with both our recent wars—in Zululand and Afghanistan; while some notes by Brevet Major T. Fraser, R.E., on *Military Engineering Incidents in the Russo-Turkish War of* 1877-8, and some particulars of Russian Military Railways in the same war, by Captain M. T. Sale, R.E., give very useful information.

A short paper by Major R. Y. Armstrong, R.E., on *A Permanent Standard Cell*, read originally before the Physical Society, is worthy the attention of all electricians.

Our readers will be glad to see another paper by Colonel T. Inglis, R.E., on *Targets for the Trial of Recent Battering Ordnance*, which brings our information on this head down to a very recent date.

A paper on *Plevna*, which has been most carefully prepared by Captain G. S. Clarke, R.E., is too bulky to be included in the present volume, and will itself form Vol. V., and be issued immediately.

ROBT. H. VETCH, Major, R.E.,

*Secretary, R.E. Institute, and Editor.*

*December*, 1880.

# CONTENTS OF VOL. IV.

## No. 12.



## No 13.

# LIST OF PLATES AND TABLES.

# PAPER I.

# LAAGERS IN THE ZULU WAR.

By Lieut. R. da Costa Porter, R.E.

Most wars have some prominent characteristics by which they are remembered in after years, and by which they are distinguished from other campaigns, and the Zulu war will, I should imagine, always recall visions of ox-driving and laager building to those who took part in it. I propose in the following paper to put together in a more or less connected form some of the notes I made during the expedition, concerning the construction and object of a few of the laagers used in that part of the theatre of war in which I served. I wish it, however, to be understood that I do not intend describing these laagers in detail, nor do I wish to enter upon any account of the minutiæ of their construction. Their trace was usually too simple, their execution too commonplace, to render such a description interesting or profitable. I want to point out the various conditions under which these laagers were designed, the reasons for which certain forms and sections were chosen, and such peculiarities concerning laager warfare as are hardly to be found in the authorised text books; but, at the same time, I hope to avoid overloading my paper with details and dimensions which are at their best imperfect imitations of the types of field works taught at Chatham.

The laagers used may be divided into six classes :—

(1). Permanent laagers for border defence.

(2). Laagers made for the defence of stores.

(3). Laagers for large forces in semi-permanent camps.

(4). Laagers for semi-permanent posts along the line of communications.

(5). Wagon laagers on the line of march for a large column.

(6). Laagers on the line of march for small bodies.

### (1.) Permanent Laagers for Border Defence.

These may be divided into two sub-classes.

(*a*). Laagers that were constructed before the war for the protection of the population. Examples—Greytown and Fort Pine.

(*b*). Military posts established during the war. Examples—Immiga, Helpmakaar, Rorke's Drift, Dundee.

Those belonging to class (*a*) are usually oblong in shape, having flanking towers at two of the opposite angles. The walls are of masonry, about 10 feet high, loopholed throughout, and surrounded by a V shaped ditch. Simple as it is, this form of entrenchment is eminently suited to its purpose. Opposed to an enemy without artillery, the masonry may be as safely exposed here as it used to be in the castles of the middle ages. The Zulus not possessing scaling ladders, or an organised drill for their use, a moderate height suffices to keep them out of the work. Being built of good masonry repairs are seldom wanted, and a harbour of refuge is thus always ready to save the inhabitants from what has hitherto been deemed an ever-present peril.

The military posts of class (*b*) are constructed under much the same conditions as those of class (*a*), so far as the enemy is concerned, but the necessity of making use of such material as could be most easily obtained has caused them to differ very considerably in character, while the choice of site would seldom be determined in the simple manner which obtained for those of class (*a*). Military considerations of various natures frequently led to these forts being placed on sites, which, so far as the works themselves were concerned, were radically bad. At Immiga, the object was merely to construct a work capable of holding a battalion of the native contingent (Major Bengough's), and hence there was considerable latitude of choice. In this case, a small isolated hill in the middle of a plain, was crowned by an irregular oval-shaped work, the wall of which was built of loose stones. As it was always deemed possible that in case of an attack the natives forming the rank and file might disband, the fort was divided into three portions, the middle one acting as a sort of cavalier, (its command being about 6 feet greater), into which the 70 white N.-C. Officers and Officers of the regiment might retreat.

At Helpmakaar, the site was practically determined by the existence of some commissariat stores, which had been erected before it was deemed neccessary to fortify the post. When, after Insandhlwana it appeared not unlikely that an attack might be made upon this place, a hasty attempt was made to throw up an entrenchment round the stores; this entrenchment was afterwards converted into a fort, although the site was not one which would have been chosen had it not been for the pre-existing commissariat arrangements; here the soil proved favourable for digging, and consequently an earthern parapet and deep ditch were formed, the whole being surrounded by a formidable abattis.

At Rorke's Drift, another unfavourable site had to be selected. The fort at this post (I am not talking of the temporary one erected at the scene of Major Chards' defence, but of the semi-permanent one made afterwards) was built on a high bank overlooking the river, from which the posts, and some store-houses which were to be (but which never were) erected, could be defended; in this case, the rocky nature of the soil necessitated stone work, and as the first orders issued were for the construction of a permanent laager, the walls were commenced in masonry; when subsequent orders arrived that a permanent laager was not required, an attempt was made to hasten the progress of the work (the rate of which had hitherto been governed by the number of masons available) by forming the two sides not as yet commenced of earth-work; by dint of much blasting, a rough ditch, 6 feet deep, was made, and enough earth was obtained to form the parapet, the inside revetting being built with stones; by the time one face was made an alteration was made in the section.

In olden days, the full revetment was abolished in favour of semi-revetment, because by this change only could the power of artillery be neutralised; at the same time, the full revetment gave a better profile, both as regards the amount of earth required for the parapet, and as a protection against escalade; in a similar manner it was argued, that, as the Zulus possessed no artillery, a full revetment would be a better protection against their superior numbers than an ordinary earth parapet, more especially when, as in this case, no satisfactory ditch could be formed. The exterior slope of the parapet was therefore cut away, and the outside revetted with loose stones the ditch being widened to get rid of the new berm so formed; as, however, the two stone revetments, the inside and the outside, were together a sufficient protection, the earth between them was evidently superfluous, and so, in a somewhat roundabout way, the conclusion was arrived at, that, in a stony country like the present theatre of war, and against savages who possess no artillery, the loose stone wall should always supersede the earth-work wherever possible. The remaining face was therefore constructed in this manner, thus giving the fort a very patchworky appearance.

The fort at Dundee was placed in an open plain, in soil which was very favourable for digging, and which supplied good sods; an excellent earth-work might have been formed here, but for the reasons stated above, earth-work was no longer deemed necessary. As stones could not be obtained, while excellent sods were easily got, it was determined to build a sod-work fort with a ditch of good profile; the result was very satisfactory, and the Dundee Fort was undoubtedly the neatest and most complete work of the kind we built. It was square in shape with two rounded flanking towers, the ditch V shaped, the walls loopholed, and between each loophole was a small step, by means of which the defenders could fire over the parapet if this were deemed advisable.

Before proceeding to the next class of laagers, there are one or two points connected with these semi-permanent works which I wish to point out.

*Water Supply.*—In no single instance could we get good water into he forts (with the exception perhaps of Helpmakaar, where a fairly ood spring ran into the ditch), this was not however so great a drawback as it may seem. The Zulus do not appear to be capable of closely investing a fort, nor even of stopping before it for any length of time. At Ekowe, the Impi was always more or less in the neighbourhood, but at no time was the garrison shut up in its works. Rorke's Drift showed that they were capable of a prolonged attack, but having failed after some 15 hours of fighting, they withdrew altogether. So long as the water supply is under the fire of the fort, I do not imagine there would ever be any difficulty in obtaining a daily supply; if, in addition, a sufficient number of water-casks be kept filled, to keep the garrison going for 48 hours, it would appear absolutely certain that no danger of running short would ever arise.

*Strength of Garrison.*—The more rifles that can be brought to bear upon the enemy at a time, the quicker will that number of them be shot down, which will induce the remainder to turn tail. Compare the duration of the attack at Rorke's Drift, Ginginhlova, Kambula, and Ulundi, with the number of rifles available, and the number of the enemy killed. As the loss of the defenders will vary inversely (other things being equal) with the duration of the attack, it is of importance to reduce that duration as far as possible, and hence as many rifles as the parapet will conveniently hold (say one per yard) should be available. At Rorke's Drift 20 per cent. of the defenders were hit in 14 hours; at Kambula 5 per cent. in four hours; at Ulundi 2 per cent. in $\frac{3}{4}$ of an hour. The argument often used during the war, that a certain number of men would hold a fort *safely* (say two men to three yards), was only of value if the number of lives lost in the defence were a matter of no importance; or if the number of men available for the garrison could not be increased. In addition to the one man per yard, a small proportion, say one-fifth, would be required as a reserve; but in the absence of artillery or escalading, the large reserves told off in European fighting would be quite out of place.

*Loopholes.*—While loopholes certainly add greatly to the safety of the defenders, they as certainly diminish the offensive power of their fire; hence it would seem advisable to offer the defenders the alternative of using them where constructed, or of firing over the parapet, if they so preferred. I have already mentioned how this was done at Dundee. Another scheme was arranged in the original design of Rorke's Drift; this was to have a high banquette inside the walls, which were eight feet high, with loopholes arranged for kneeling fire, while over-bank fire could be used standing; to save labour, this arrangement was not carried out.

*Flanks.*—The necessity for having flanks was often denied, and many arguments were held upon this subject. Undoubtedly the overwhelming power of modern weapons has increased the value of direct defence enormously, and decreased the value of flank defence proportionately; at the same time, I do not think it has quite abolished the utility of having a few rifles in positions where the foot of the parapets can be seen. Thus at Rorke's Drift more than one Zulu was killed by the flank fire from the house which formed part of the defences, while he was endeavouring to rip open the mealy bags, of which the parapet was built, unseen by its defenders.

*Obstacles.*—In many cases obstacles of various kinds were used, such as abattis, wire entanglements, &c.; but it may be doubted whether they were absolutely necessary, at the same time nothing was lost by their use, and where time was no object, everything that would add to the strength of the defence was worth trying.

*Timber.*—In a country absolutely devoid of timber and brushwood, engineering was carried on under very great difficulties. The numerous "dodges" of which use was made at Ekowe, were impossible up country, and consequently a great element of sameness was introduced into the work.

(2.) Laagers made for the Defence of Stores.

Examples—Conference Hill, and Fort Newdigate.

The object was to protect a large bulk of stores by a comparatively small garrison, and the method adopted in these cases was as follows:— A square space of sufficient size (in these cases, a little over 100 yards a side) was first marked out, on which the stores were to be placed in the way most convenient to the Commissariat officers. Two square forts were constructed on the prolongations of one diagonal of the large square, thus flanking the stores on every side. In the examples quoted, the forts were designed for one company each, and were consequently very small, about 25 yards a side. The great drawback of this system appears to be that the already small garrison of the post, is divided between the two forts, each of which is somewhat small to be exposed to a prolonged attack. The intervening mass of stores, while preventing the forts from firing into each other, (a danger which was considerably lessened by the diagonal arrangement), also hindered them from affording efficient mutual protection. Another drawback lay in the fact that the interior of the forts was too small to allow the garrison to sleep inside, while the small numbers of the force guarding the fort would preclude the possibility of an efficient system of picquets. In case of an alarm therefore at night, the chances are that the outposts would be overpowered and the enemy in among the tents before the men could be got into the forts. Two counter-proposals were therefore made, of which *Figs.* 4 and 5, *Plate* I., show the main features; according to that in *Fig.* 4, there is one central fort for two companies, the stores being arranged on its longer faces in a redan shape, so that they can be flanked from the work; in this case, the interior space of the fort, which has the same perimeter as the two forts described above, is greater than their combined spaces; but the necessity that exists for having two comparatively long faces on which to base the redans, diminishes this advantage. The arrangement in *Fig.* 5 allows of a maximum of interior space, by the use of a square fort, the stores in this case being placed in long lines radiating out from the fort. These long lines have the advantage of acting in a manner similar to obstacles at right angles to a line of battle, which do not extend beyond that line, and of further admitting of any particular article being got at more easily than when everything is piled into one large mass, as is the case with the redans. These counter-proposals were not however accepted.

(3.) Laagers for large Forces in semi-permanent Camps.
Example—Landmann's Drift.

When the 2nd Division advanced from Dundee to Landmann's Drift the battalions comprising it were ordered to entrench themselves. Square laagers with small bastion-like flanks at the opposite angles were marked out on a diagonal line, with sufficient space between them for cattle and horse laagers, these latter being made of wagons. The section employed was that shown in *Fig.* 6, *Plate* I., and the work was executed entirely by the troops who were to defend each laager. The tents were placed round the works, and in case of alarm the men were ordered to fall in on their respective parades, outside the camps, the tents being struck at once, and the laagers subsequently occupied should necessity arise. It should be noticed that the works thrown up, while affording a considerable physical obstacle to the enemy should he endeavour to close, did not afford cover to the whole of the interior space, but as these forts were constructed merely as a temporary measure, and as they were supposed to represent a type which might be employed whenever the division halted for two or more days when in Zululand, it was deemed inexpedient to expend more work upon them than might be absolutely necessary. As a matter of fact this form of laager was only employed in one other case as far as I am aware, viz., Koppe Allein, where the division remained halted for five days. The labour entailed in the construction of works of this kind is very considerable, while the protection afforded by them is scarcely so great as that given by wagon laagers, a description of which will be found further on.

(4.) Semi-permanent Forts on the Line of Communication.
Example—Fort Newdigate, Fort Marshall, Fort Evelyn, Kwamajwasa, St. Paul's.

During the advance on Ulundi it was deemed advisable to construct a series of little forts along the line of communication in order to keep open our road to the colony. The garrisons of these varied between 250 to 400 men, their distance apart averaging about 20 miles. There is little of interest to describe concerning their construction. Rapidity of execution was the chief condition which had to be fulfilled, while simplicity of trace was the natural result of the circumstances of the war. Sod walls, 6 feet high, with ditches of 2 feet and 3 feet deep were the usual type, and instructions were left with the officers commanding the forts to strengthen the works afterwards as time and means premitted.

### (5.) Wagon Laagers on the Line of March.

One of the most peculiar features of the war consisted, undoubtedly, in the huge wagon trains that accompanied the various columns. Moving through an enemy's territory, where the advance of the army scarcely made the country in its rear one atom safer than it was before, it was found impossible to employ a system of convoys such as usually obtains in civilized warfare. When the 2nd division of Wood's Flying Column left Koppe Allein and Munhla they carried with them 800 wagons drawn by more than 12,000 oxen, and occupying, when stretched out in single file at *close intervals*, a distance of 15 or 16 miles of road. With these wagons they carried to Fort Newdigate and the Upoko, a sufficient supply to last for six weeks without drawing upon the base depôts for anything further. Having reached these points an advanced depôt was formed at Fort Newdigate, while the Flying Column returned with the whole of the wagons (now empty) for a further six weeks supply. On the return of this convoy the wagons were loaded up afresh and the final advance on Ulundi commenced. To guard these long columns of wagons with the comparatively small number of men available, and that, too, against an enemy whose whereabouts must always be unknown until the moment of attack, was a task of considerable difficulty, and one which required careful organisation. Notwithstanding the disaster of Insandhlwana it was always held by the army at large, that there would be no danger in meeting the enemy in the open, provided that the troops were kept in some solid formation, and the tactics pursued at the battle of Ulundi show that this opinion was held by those in command, and that it was not without foundation. At the same time the necessity for protecting the large number of cattle, horses, and wagons from sudden attacks of the enemy was very apparent, and it was as a protection against this danger that the system of wagon laagering was regularly adopted. The description of the method employed given below is based on that pursued by the Flying Column. It should be remembered that this column usually preceeded the 2nd Division by one day's march, and that consequently its laagers were entirely independent of those of General Newdigate's force. The column consisted of two batteries, R.A., one company, R.E., three battalions of Infantry, some 500 Mounted Corps (irregulars, mounted infantry, &c.), Wood's Irregulars (natives), and the Natal Native Pioneers. A train of 300 wagons followed the column, of which about 150 formed the regimental transport, while 150 belong to the Commissariat. On the line of march the 49 wagons, field hospital and bakery, headed the column, followed by the Artillery and Engineer transport. Next came the regimental wagons of the remainder of the troops, the rear being brought up by the Commissariat Train. On approaching the camping ground the A.Q.M.G. rode forward with the camp colours of each regiment, and on arriving on the ground the corners of the three laagers arranged as in *Fig.* 7, *Plate* I., were at once marked out. The regimental colour parties then took possession of the spaces allotted to them, marking the limits with their flags, the lines thus marked represented the line of the laager, the camps being placed outside of this, each regiment in front of its own wagons. As the wagons arrived, they were brought up in the manner shown in *Fig.* 8, the pole or desselboom of each wagon being outside that next to it, its fore-wheels just in rear of the hind-wheels of the wagon in front of it. By this means the whole of the wagons could be brought into position with their teams inspanned, and, which was of even greater importance, the oxen could be inspanned next morning simultaneously. The rapidity with which a laager of this nature could be formed depended entirely upon the length of time occupied by the wagons in coming upon the ground; its formation could be carried on at a dozen different points simultaneously, one officer from each regiment superintending the arrangement of that section of the line belonging to his own regiment. The number of troops in the column did not suffice to man the whole of the three laagers shown in the figure, and consequently the cattle laager was left practically undefended. The main laager was defended by the troops encamped round it, and from it two sides of the cattle laager could be flanked one regiment was told off to a small laager on the far side, from which the remaining two sides could be seen; and thus the whole of the cattle laager was indirectly defended. In addition to this, the whole of the native troops were told off to garrison it, not that much reliance could be placed upon them, but because it was thought that by this arrangement they would be less likely to cause any confusion among the white troops should a panic seize them. When an attack was deemed imminent (as for instance when the column first arrived at Nonduini), further arrangements were at once made; the wagons, instead of being drawn up in a rough echelon, were placed end on, the poles being run between the hind wheels of the wagons next to them; as each wagon occupied five paces when so closed up, a garrison of 10 men per wagon would give the same amount of fire as infantry in line, and in this case five men were placed on the wagons, and five underneath. The stores in the wagons were converted into a rough breastwork for those above, while earth was piled between the wheels underneath to afford protection to those below. This system however had the drawback of delaying the start next morning considerably; not only had the stores to be rearranged and the wheels cleared of the earth placed between them, but every wagon had to be shifted to get the poles clear in order to allow the oxen to be inspanned; this last source of delay was greater than may perhaps be thought likely by those who have not had to deal with the heavy South African bullock wagon. It was found moreover that the garrison of the main laager was larger than this method of defence required, and that consequently more rifles were kept idle in reserve than was prudent. During the late stages of the advance, therefore, a shelter trench was constructed outside the wagons and held in the ordinary manner, a second tier of fire being obtained by placing men on the wagons in rear, without however disturbing the ordinary arrangement of the poles.

As it was always deemed possible that an attack might be made on the column while on the line of march, it was necessary to have some organised method of forming laager as rapidly as might be. The cavalry foreposts were supposed to ensure a warning of at least three quarters of an hour to an hour, and hence it was deemed that any system that would admit of laagers being formed in less than that time, would be more satisfactory; for this purpose the line was divided into three parts, the defence of each of which was confided to one battalion. On the word being passed to form up for defence, the head of each section of the column was to halt at once and laager was to be formed upon it, the three laagers being thus formed simultaneously; in the few cases where the wagons had to be in single file, this would still have taken two hours, and the laagers when formed would have been five miles apart. As a rule, however, the column was able to march with from four to eight, and even ten wagons abreast; with four abreast, the laagers would be formed in a little over half an hour, and they were then about three quarters of a mile apart. Such a formation would undoubtedly have puzzled the enemy considerably, his usual surrounding tactics being scarcely applicable. When the passage of a defile of any kind had to be effected, the danger arising from the long "tailing out" of the column was guarded against by the leading wagons being halted as soon as they were clear of the difficulty, and a rough laager formed as those in rear gradually came up; this necessarily delayed the march considerably, but it prevented the long train from getting out of order.

### (6.) Laagers for small Bodies on the Line of March.

It was of course quite impossible to lay down any definite regulations to guide officers in charge of small columns, and beyond the general order that their camp must be entrenched in some way every night, everything had to be left to their own discretion; however great the danger, real or imaginary, of allowing single companies to move about alone, it was not possible to avoid doing so occasionally, and as these companies seldom had enough transport with them to form wagon laager, some other plan, or at least some modification of the usual system, had to be adopted. In Natal itself but little difficulty was usually experienced, as the detached farm-houses along the border could ordinarily be employed as the basis for an entrenched camp; in Zululand, however, the only available plan appeared to be to use the wagons as far as they would go, and employ trench work for the remainder. *Figs.* 9 and 10, *Plate* I., give a specimen of the laager employed. *Fig.* 11 is a specimen of one used by the 5th company, R.E., when on the Mivi River.

When the Flying Column of the 2nd division crossed the Umvolovsi, to advance upon Ulundi, the whole of the wagons and oxen were left behind, their defence being intrusted to the 1/24th Regiment, and the 2nd Company, R.E. *Fig.* 12, *Plate* I., shows the arrangement adopted on this occasion.

R.daC.P.

*St. Pauls, Zululand,*
*15th August*, 1879.

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## APPENDIX I.

## NOTE ON THE FORM OF LAAGER GENERALLY USED BY THE 2ND DIVISION UNDER MAJOR-GENERAL NEWDIGATE, C.B.

By Captain D. C. Courtney, R.E.

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On page 9 Lieut. Porter observes that the Flying Column Laagers were independent of those formed by the 2nd Division; as the latter were also different in some respects, a slight description of them is appended.

One large laager was formed instead of three, and the interior space divided into two unequal parts by a traverse of wagons, the larger part being assigned to the draught oxen, and the smaller to the horses and encampments for the staff, hospital, etc.

A shelter trench was thrown up a yard or two outside the wagons, and it was intended to limit the defence to it, as it was feared that a second line of fire from the wagons would just catch the heads of the officers superintending the firing from the trench.

The rough sketches annexed (see *Plates* II. and III.), show the arrangements for occupation and defence. Three guns were posted behind breastworks at each angle.

*9th April*, 1880. D.C.C.

## APPENDIX II.

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### GENERAL REGULATIONS FOR THE 2ND DIVISION, UNDER MAJOR-GENERAL NEWDIGATE, C.B.

1st.—Line of wagons, 220 × 320 or 1040 yards perimeter.
2nd.—Area, deducting passage, 200 × 300 = 60,000 yards super.
3rd.—Tents to be pitched 10 yards from trench.
4th.—Trench two yards outside wagons.
5th.—Traverse of wagons 190 yards from front line.
6th.—Regimental horses not to be picketed in any place except as shown.
7th.—No tents in laager except Army Head Quarters, Divisional Quarters, Hospital, Hospital, Commissariat, and Grooms.
8th.—Regiments responsible that entrances are left opposite companies.
9th.—Transport Officers that entrances are left for cattle and horses.
10th.—Horses of mounted natives to be picketed in line, and not scattered about.
11th.—Latrines to be dug 150 yards from tents.

# PAPER III.

# THE FORTIFICATIONS OF DELIGRAD

AND THEIR INFLUENCE DURING THE

# TURCO-SERVIAN WAR OF 1876.

(From *Streffleur's Austrian Military Review*).

Abstracted from a French Translation in the *Bulletin de la Réunion des Officiers*,

BY MAJOR C. WOODWARD, R.E.

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RECENT events have made the name of Deligrad familiar to all who have studied the course of the Turko-Servian War. A glance at the history of Servia and the adjacent provinces will show that in the determined contests in which the Serbs have attempted to recover their independence, Deligrad has always played a most important part as an obstacle hindering the approach of the Turks to the heart of the country. Even to this day the dilapidated ramparts of the celebrated works raised to defend the defiles of the Morava prove the great value of this strategic point.

The position was first selected and occupied by Peter Dobrinjatz in 1806, when he defended its entrenchments against a far superior Turkish army for six weeks. In 1809, after the defeat at Nisch, the Voivode Milosch took refuge there, and the next year Wuzica heroically defended them against the whole army of Kurchid Pacha. In the war, therefore, of 1876, the necessity of increasing the defensive strength of the position was perfectly understood. At first it was only proposed to resist an enemy coming from the south by the right bank of the Morava, but after the combat of Prejilovika the impossibility of the enemy's approaching the position by that route only was recognized, and the works of defence were extended to the south and west, thus creating the positions of Bobowitz and Djunis. The works round Deligrad became then dependent on those of Djunis.

Thus, therefore, although the three fortified positions named above really constitute one grand system of defence, called the position of Deligrad, it will be convenient to examine them separately. Their creation was not simultaneous, and each formed a separate command, and while the works of the two last named positions were engaged in the action which took place on the Morava, those of Deligrad fell without being directly attacked.

### Position of Deligrad.

Deligrad (see *Plate* I.) is situated on a stream of the same name, scarcely four leagues from the frontier at Alexinatz, and on the road from Belgrade by Paraschin and Razany to Alexinatz and Nisch. Besides a large school and two inns, constructed of masonry, the village only contains seven houses in *pisé* separated by a narrow street from the village of Jabukovatz.

The ground extending in front of Deligrad to the south forms a plateau of which the north-east portion rises in a gentle slope crowned with hillocks. This uniform plateau, cut only by two nullahs, of which one is dry, from east to west, extends to the south as far as Neritjef-Mehana, where it is bounded on the east by the river Jasenje, and on the west by ravines. From this latter boundary there extends to the Morava a fertile plain, which at Bobowitz is only separated from the valley of Alexinatz by a narrow strip of country. The northern edges of the plateau falls in a scarped slope to the Deligrad stream, from which it is separated by the Czerny-Kao hill.

The road from Belgrade to Alexinatz divides the plateau into two unequal parts. The largest portion—that towards the east—is slightly undulating in places, and is bounded on the east by a thick forest. It consists chiefly of ploughed land, but there are also some vineyards. The whole of the western portion is cultivated except a small wood near Vikaschinovatz. The nullahs before mentioned are crossed by trestle bridges on the main road. The undulations of the ground and the nullahs give cover from direct fire, and the thick wood on the east permits of approach under cover to its northern edge, as in spite of its thickness it is easy to pass through it.

Close to Deligrad, and below the plateau, the road to Krujevatz turns off at an inn. After crossing several bridges it passes the Morava on two pontoon bridges, and then turns to the left to Djunis. From Mehana (Deligrad) a country road goes to Mozgova, where it meets the road to Lukova and Banja. A road passing along the Praschkovatz valley, and crossing the stream of that name three times on wooden bridges, joins the Alexinatz and Krujevatz roads. This road is flooded during the rains.

The "carriage road" which, turning off from the Krujevatz road at the Morava, joins the Belgrade road at Razany, is not practicable for military convoys without great improvements, since the light country carts can only make use of it in dry weather.

Large masses of troops with their trains moving from south to north are therefore constrained to use the Belgrade road, for the outlets existing to the west and north of the Czerny-Kao, without taking into consideration the forests covering them, are so sunk in the ground, and are of so variable a character, that they must be considered impracticable, even for small bodies of troops. The country road from Mozgova to Razany was somewhat improved before the war, but the improvements were only partial, and it therefore was of but small service.

The St. Roman Mountain, separated from this line of road by the valley of Praschkovatz is, like the latter, wooded and very impracticable.

The water courses comprised in the position of Deligrad are the Bulgarian Morava, the Czerny-Reka, the Deligrad, the Praschkovatz, and the Jasenje.

The Morava, with its numerous and strongly pronounced windings, belongs to all the three positions. Starting from Alexinatz it traverses, within banks varying from 3 to 13 feet in height, a fertile and cultivated country, and after winding round the position of Djunis flows between Maletin and Trubarove in the midst of wooded hills, and thence to its junction with the Servian Morava, it is generally confined within scarped banks. Its waters, usually very clear, flow with a velocity of 4 feet per second over a rocky bed, having a mean width of 44 yards and depth of 3 feet 3 inches. But after rain of only an hour's duration the water becomes yellow and muddy, and after continuous rain for some hours moves pretty large pebbles, and often overflows the right bank, which is generally flat. The water of these floods finding no outlet accumulates in the low portions of the ground and forms marshes.

To cross this river there is, besides the two bridges of boats before mentioned, another at Alexinatz, and at times of low water, and even when the river has its normal depth, there are several fords.

The Czerny-Reka, coming from the Czerny-Kao, has a very rapid current running between high and steep banks into the Morava. It can only be crossed on bridges or down ramps cut in the banks. The Deligrad, on the northern edge of the Czerny-Kao plateau, discharges its turbulent waters into a marsh not far from Jabukovatz. It is crossed at the latter village and at Deligrad by three wooden bridges. The Jasenje stream crossing the road under a bridge at Neritjef-Mehana forms the southern limit of the Deligrad position and the northern limit of that of Bobovitz. From Jasenje to its junction with the Morava the banks of this stream are marshy and impracticable for carriages. Finally, the Praschkovatz stream empties itself into a branch of the Morava.

All the water courses are so flooded in the rains that the roads, which in ordinary times are firm, are covered with water along large portions of their length in the plain.

### Position of Bobovitz.

This position is contiguous to the sector bounded by the Jasenje stream up to half a league from Alexinatz, and extends between the Belgrade-Alexinatz road and the Morava. The lower slopes of the hills, heavily wooded, which command the road, form here two great spurs; that above the road is completely open and extends to the village of Bobovitz, which can be perfectly seen from the side of the hill, the view not being masked by the large fruit gardens surrounding the village, nor by the forests which adjoin them. The lower space forms the site of the village itself, with its mud huts, and extends to the village of Kötschi, which is in the forest. It is 32 feet below the upper space, and is itself about the same height above the plain below, which is here, and in the large bend of the Morava, very undulating, while in front of Jasenje and Kötschi it is open and easy to be traversed, although completely commanded by the two spurs. At the foot of the lower spur, in the west of Bobovitz, is a marsh 100 feet wide, practicable in places, discharging its surplus water into the great bend of the Morava by a ditch, sometimes dry.

At this point the left bank of the Morava everywhere commands the right; both are very scarped, and vary in height from 12 to 16 feet; the depth of the river rarely exceeds 3 feet, and in some places, as at Trujan and Korman, there are fords. But though the right bank is commanded by the left, large thickets conceal the plain in front as well as the village of Bobovitz, in spite of its elevation.

There are, within the Bobovitz position, only the main road from Belgrade to Alexinatz, and two country roads, one from Klövtschi to Trujan, and one leaving Alexinatz, which crosses the maize fields and a ford on the Morava to the village of Dolni Adrovatz.

### Position of Djunis.

Facing the sector just described rises Mount Djunis, the western slopes of which are wooded. This elevation takes its rise opposite Alexinatz, and extends rising to the north like a quoin. Its summit forms a species of plateau on which rise here and there some isolated wooded hillocks. In summer this mountain is completely deprived of water as far as Dolni-Ljubes, where the stream of that name is never dry; its southern portion is practicable, whereas on the north all manner of communication is impossible. It completely commands the whole valley of the Morava. At its eastern foot passes the Krujevatz road, from which, at the Pioneer Barracks, a well-kept road leads to Alexinatz. On this road are many insignificant hamlets, of which only that nearest Alexinatz possesses masonry buildings.

As indicated by its name this chain of heights follows the road from Krujevatz to Djunis, but the position itself of Djunis only comprehends that part of the fortified heights to the north of the Dolni-Ljubas stream and the portion south-west of Krevet.

Above the last-named stream the position is flat and heavily wooded, the works being completely surrounded by forest. As there are no roads by which the lines of entrenchments can be reached, it is necessary to take the culminating point of the ridge as a landmark; this is occupied by the redoubt No. III., and from it a view of the valley of the Morava and the Krujevatz hill is obtained. The wooded flanks are also escarped, and in places rocky and ravined.

The convent of St. Nestor is reached by a path following the gorge, and not far from the main road to Krujevatz. To the east of Djunis the slopes are more accessible, and the hill sides are planted with vines.

### FORTIFICATIONS OF THE POSITION OF DELIGRAD.

Some time before the commencement of hostilities it had been determined to form a defensive position at Deligrad, in order to oppose a final and energetic resistance to a victorious enemy advancing along the Alexinatz-Belgrade road, before he was able to seize the Morava defile, for, this defile lost, nothing intervened to oppose a rapid march on the capital.

The works of defence were commenced sometime before the war by Servian Officers of Engineers with the help of the pioneers and militia, but they were far from being completed when the Turks appeared before Alexinatz. Then, while headquarters were oscillating between Alexinatz and Deligrad, the officers who had hitherto directed the works were sent in hot haste with the pioneers to fortify the position of Alexinatz, and officers who were not attached to troops left Deligrad on various duties, so that there only remained with the militia of the 1st and 2nd class, who were left to complete the defences, the young *feldwebel* of pioneers, Manoljo, on whom devolved the direction of the works and the command of the troops. Under these circumstances the works were executed exactly as originally sketched out, and even after the arrival of the commandant of the position, Lieut.-Colonel Alexander Nikolich, of the Engineers, nothing was done to rectify the many defective arrangements made by the *feldwebel*; indeed, far from troubling himself about them, Nikolich, it would seem, was only too glad that the construction of these fortifications had been taken out of his hands.

The question of completing these works as a system under one chief command was only taken up again when, the enemy having concentrated *en masse* before Alexinatz, it was feared at headquarters that they also might suffer the fate which had overtaken that town. Nevertheless, even then the works were not completed, but attention was directed rather to execute indispensable modifications in them as well as in the fortified position generally, since after the affair of Prejilovika the officer in command had at the same time to take in hand the position of Djunis, where much remained to be done.

According to the original design Deligrad was to be defended by 13 works, some closed at the gorge, others half closed, and the rest completely open, besides shelter trenches and batteries. The defences were commenced according to this project, and in the middle of August the various parts were in the following stages of progress :—

No. I. A square redoubt, with blindages in the interior, and additional defences before the face and flanks, was completely finished.

No. II. was formed by two advanced lunettes, only half completed. The parapets and accessory defences and the palisading of the gorges were finished.

No. III., consisting of three traversed batteries, shelter trenches and improvised entrenchments, was nearly finished, together with the covering abatis.

No. IV. A square redoubt, with indented faces, was finished.

No. V. A similar work, was nearly completed, and only wanted the accessory defences, the planks for the platforms, and the covering over the blindages next the parapet.

No. VI. was an open redoubt, scarcely commenced.

No. VII. A redoubt half completed, but still requiring much excavation in the interior, and in the ditch of the face and the right flank ; the accessory defences, moreover, were not commenced, though the materials had been assembled.

No. VIII. A redoubt wanting the enclosure at the gorge, its interior organization, and a portion of its accessory defences.

No. IX. was to have been composed of two advanced flêches, but that on the left had been transformed into a lunette by the *feldwebel.* Both were nearly completed.

Nos. X. and XII. Two closed redoubts were but half finished.

No. XI. A battery epaulment with traverses was complete.

No. XIII. still wanted its internal organization, the ditch of the gorge at the entrance, and the accessory defences before the right flank.

A redoubt had been half completed on the Czerny-Kao in order to oppose the march of an enemy coming from Mozgova, but the Servian Captain of Engineers, Ivisch, on his own authority, caused it to be demolished.

On the 16th August only the works Nos. I., III., IV., V,, and XI. could be considered to be in a state of defence ; but that simply means that they were ready to receive their guns and garrison, which had not yet been detailed for them.

Besides the above works there had been constructed on the left bank of the Deligrad two large powder magazines, a field bakery, and all the various provision stores ; the hospital and the quarters for the headquarter staff were disposed in the ground at Mehana. The troops camped in the wood in rear of the fortifications on both sides of the road.

The relief of all the works, no matter what their position, was 6 feet 6 inches ; the thickness of the parapets on the faces and flanks was 12 feet 6 inches, and at the gorge 8 feet ; the ditch was 13 feet 9 inches wide at top and 10 feet 6 inches deep ; the bottom of the ditch had a width of 4 feet 4 inches when the section was not triangular. Nos. I. to IX. had a glacis 3 feet 3 inches high at the crest, and a length of 15 feet 6 inches ; the others had no glacis.

The scarp was everywhere in the prolongation of the exterior slope, which was made at the natural slope of the earth. The superior slope was always $\frac{1}{7}$, without taking the nature of the approaches into consideration ; the interior slope was 4 feet 3 inches high. All the steep slopes were revetted with sods or hurdles. The banquettes were generally arranged to receive two ranks of infantry, and were, therefore, 4 feet 3 inches wide ; their rear slopes, except where blindages had been constructed near the parapets, were at $\frac{1}{2}$, terminating at the bottom of the interior ditch 3 feet 3 inches deep, and generally triangular in section or having a bottom width of at most 2 feet.

The entrances into the closed works were covered by traverses at a distance of 10 feet, of sufficient length to protect completely the interior. Nos. IV., V., VII., VIII., X., XII., and XIII. had also traverses containing shelters and magazines completely or partly finished. The works intended to receive artillery were also provided with platforms, under which small magazines were arranged. Except in No. I. and at the left shoulder of No. IV., the guns fired through embrasures, the cheeks of which were sodded. The platforms had been very solidly constructed, but there existed no shelter for guns not in action.

In Nos. I., IV., V., VII., X., XI., and XIII. the enclosure at the gorge consisted of a straight line of parapet 6 feet 6 inches high and 8 feet thick ; in No. I. this parapet was broken to cover the entrance. The lunettes were at a later date closed by tambours.

All the battery epaulments were traversed and provided with small shelter trenches for the gunners, but without expense magazines. The entrenchments for the infantry had a depth of 3 feet 3 inches behind the parapet, the ditches being 3 feet 3 inches wide with natural slopes. The shelter trenches were generally arranged for men standing. The accessory defences consisted of large and small trous-de-loup in three rows, small pickets, networks of iron wire, and of abatis insecurely fixed into the ground at about 55 yards in front of the entrenchments.

### Modifications and Details of the Deligrad Works.

The works may be divided into those belonging to the first line, and those in the second line. The object of the former was to directly combat the enemy ; that of the latter was to dislodge the enemy from any work of the first line into which he might have penetrated.

Redoubt No. I., capable of containing one battalion and 6 guns, was specially devoted to keeping the Alexinatz road and the ground as far as the Morava under its fire. It was situated about 437 yards in advance of the road to Jabukovatz, and there existed, at about 110 yards in its front, a hollow, about 16 feet deep, which could be but imperfectly defended from it. Its left flank, in front of the school, swept the road, crossing fire with Nos. III. and IV. ; it also could have commanded an undulation of the ground in front of the southern portion of No. IV. But this latter advantage was lost on account of the headquarters having been established in the school-house, and barracks, stables, and huts having been built in front. The superior slope of the parapet being at $\frac{1}{7}$, the right flank could neither sweep Jabukovatz nor the fruit gardens surrounding it, because the work itself had been placed too far behind the edge of the plateau, which here commands the village by 49 feet. The redoubt was surrounded by accessory defences, except on a width of 13 feet left for an entrance.

In the interior, blindages had been arranged all round the work as shown in *Fig.* 1, *Plate* II. The entrance was by means of ramps into a shelter trench, in which were drains, and thence, through a door easy to be barricaded, into the blindage. The interior of this, 17 feet 3 inches wide, was covered by baulks touching one another, over which was a layer of earth filled in to the level of the banquette, and having a rear slope of $\frac{1}{2}$.

Under the platforms were expense magazines, reached from the interior ditch ; they were lined with planks or scantling.

At the salients and on the centre of the faces were positions each for two guns.

This work was afterwards modified. The accessory defences before the right flank and the corresponding portion of the gorge were suppressed, and shelter trenches were established at the edge of the plateau to sweep the approaches, and a ramp was constructed to permit of the retreat of the garrison if necessary. Shelter trenches were to have been established on the edge of the undulation of the ground previously mentioned, on which are placed the barracks, &c., at the headquarters, in order to reinforce the front fire of the redoubt, and also to flank lunette No. II., but these small works were never completed.

The two lunettes forming the work No. II. were placed in front of No. I. to afford a musketry defence on the salient, and to reinforce the action of that work which was too far behind the edge of the plateau. Each lunette was for a company of infantry, and they were so far completed that only half the enclosure of the gorge remained to be done.

No III., consisting of a continuous line, leaving a passage open for the road, contained three traversed batteries, each for six guns, in front of which were covering ditches and shelter trenches mutually flanking one another at 55 yards, in front of which again were three rows of abatis. This continuous line followed the crest of a gently sloping valley between the road and No. IV., and commanded with a heavy fire the ground on the left of the road, while the ground on its right was completely masked by the school-house and the barracks, huts, and stables, constructed immediately in front of the batteries and shelter trenches, by order of Col. Alexander Nikolich. The axis of the embrasures in the batteries in rear of No. I. were directed to sweep the space between the left flank of No. I. and the school ; those of the embrasures of the batteries at the Upper

Mehana were directed between No. II. and the road, and the battery nearest No. IV. crossed its fire with the two preceding batteries. A passage for sorties was left between the centre and left batteries, and the ground in front was completely cleared of obstacles.

The faces of redoubt No. IV., constructed for one battalion and four guns, could hardly see the slope in front of the abatis, and therefore had no action on the steep upper slope of the mamelon on which the work was placed, nor the gentle slope beneath. The front of this redoubt should have been retired 33 feet behind the brow in order that the accessory defences in front of the ditch might be placed on level ground and not on an inclined surface.* The left salient had a *pan coupé* for two guns *en barbette*. The left flank was intended to sweep the ground in front of No. V., and the right flank that in front of No. III. The approaches to the gorge were flanked by No. V. The parapet of this work was afterwards lowered by 10 inches in order to have a good view of the abatis in front.

Between Nos. IV. and V. a simple battery epaulment was thrown up to sweep the approaches on the west to the wood in front of No. IX. It was intended to construct, also, shelter trenches in front of the abatis before this battery, but they were not executed. The battery had hollow traverses on its terreplain as shelters for the garrison.

The hollow traverses in the interior of the works do not seem to have been constructed on any fixed system as regards direction: they were simply intended to procure shelter. This want of system appears to have been based upon the idea that no turning operation by way of Mozgova was to be apprehended. The section of a traverse is shown in *Fig.* 2, *Plate* II. The part of a traverse under which magazines were placed was broken *en crochet* and its interior lining was separated from that of the traverse by a merlon: steps led from the former part of the traverse to the magazine.

No. V. was constructed for a battalion and six guns, and its site was well chosen to flank the edge of the wood in front and the slope of the hill before No. IV., and also to give a good front fire. The guns were placed in pairs at the salients. The accessory

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* This opinion and the reason given for it do not seem clear, though it would, perhaps, be difficult to find other reasons. (*French Translator*). Perhaps it is meant that the accessory defences should be under the fire of the work, which they would not be if constructed on a steep slope not seen from the latter.—C. W.

defences, interior traverses and platforms of this work were continued and completed.

No. VI., situated at 328 yards from the last work was for half a company, and its object was to guard the long interval between Nos. V. and VII. The guns fired *en barbette*. Instead, moreover, of forming the work as a lunette, which had been intended, a long face was constructed with short flanks; the thickness of the parapet was 9 feet, and its height 4 feet 1 inch.

No. VII., commenced for a garrison of one battalion with four guns, was but partially completed. The guns, placed in pairs at each salient, fired, contrary to the original intention, *en barbette*, with a range all round, crossing their fire with that of the adjacent works. Interior shelter trenches, 5 feet wide at bottom, followed the trace of the parapet, and a blindage was afterwards constructed by the garrison itself. The work was covered by accessory defences.

No. VIII. was a redoubt for one battalion and six guns, its principal faces being directed against the wood, upon which the embrasures were turned. The left face was to defend the eastern edge of the wood. The left flank was directed towards the country road from Mozgova, and was to have been defended by infantry only, but two embrasures were afterwards constructed in it. The enclosure at the gorge was not completed, but the garrison excavated shelter trenches at the foot of the parapet, and formed a blindage.

The works composing No. IX. were constructed in front of No. VIII. to sweep the ground between the edge of the wood and the plateau, an object they did not, however, fulfil, on account of their great distance from the edge of the latter; shelter trenches were therefore formed along the crest in advance of the works. The garrison for No. IX. was 300 men, and the works were completed.

The redoubts Nos. X. and XII., by their commanding position, dominated the works in the first line, and the steep banks of the stream in front forbad any attempt upon them from the front. They were constructed each for two companies and four guns during the final combats at Alexinatz. This interior was arranged as in the works of the first line, and their guns fired through embrasures. Two embrasures in No. X. were directed against Nos. IV. and V., and two on the space between Nos. VII. and VIII. Two guns in No. XII. also swept the same interval; the others flanked the left of No. VIII.

No. XI. was a traversed battery for 12 guns directed on the space between Nos. VII. and VIII.

No. XIII. occupied the summit of a rounded hill, and was absolutely inaccessible by the front. It was constructed for one battalion and four guns, two of which commanded the junction of the Krujevatz and Belgrade roads, and the embrasures of the two others were directed on the ground towards Dolni Ljubes and Viktovatz. A barbette for two guns was also arranged on the capital of the redoubt, the remblai for which was obtained by levelling the interior. Three lines of shelter trenches were to have been constructed by the garrison in front of the right flank, but were not executed, the labour being devoted to the construction of blindages within the redoubt

While the various fortifications above described were being carried out, a company of pioneers was engaged in constructing, above Jabukovatz, two batteries for 12 guns, in order to command the plain to the west of that village. A road was also constructed from the Lower Mehana* along the rear of the fortified position, passing by the powder magazines, one from No. III. to the other side of the valley, and two uniting Nos. X. and XII., with the country road to Razany. These roads were absolutely indispensable, as the works in the first line had no means of inter-communication save by the country road in front, and their gorges were only accessible to men on foot.

The task of completing and modifying the fortifications was commenced on the 19th August by 1,200 militia. The sudden arrival of the captain of engineers, Ivisch, retarded the progress of the work, since on his own single authority he took off 600 men to demolish a redoubt on the Czerny-Kao on the left flank of the position, which was half completed. He also gave peremptory orders to the *feldwebel*, Manoljno, not to execute any other work after this demolition. Col. Alexander Nikolich, the commandant of the position, suffered this arbitrary interference with his authority passively, confining himself to expressing his discontent by some energetic expressions. The colonel had, however, taken the initiative in nothing requiring the exercise of responsibility, and, in fact, had opposed even urgent and most useful propositions on that account,

* Upper and Lower Mehana are evidently two portions of the village situated on the bank of the Deligrad stream, and on the main Alexinatz-Belgrade road. It is called Deligrad on the plan.—C. W.

leaving everybody to act as he pleased. Thus he declined to order the destruction of the school-house or the construction of shelter trenches in front of No. II. But he took away workmen employed on those trenches to construct quarters for his own convenience on the road directly on the right front of No. III.

### Observations on the Position of Deligrad up to the Combat of Prejilovika.

It has been before stated that the position of Deligrad was completely deficient in flank defence on the side of Mozgova, and that the only work commenced on that side (the redoubt on the Czerny-Kao) was demolished before having been completed. This total neglect of the left flank might, as will be seen, have led to fatal results for the position. After Kniajevatz and Zaitschar had been captured by the Turks the Servians fortified Lukova and Banja, but after the enemy had moved from the valley of the Timok into that of the Morava they concentrated their own forces at Alexinatz, leaving only three battalions in each of those two positions. They then seem to have supposed that after the capture of Alexinatz the enemy would be compelled to attack Deligrad in front on the Belgrade road. This supposition was quite erroneous, since the enemy could not fail to send a portion of his force by the Alexinatz-Mozgova country road in order, at least, to assure his flank, and this flanking column would have encountered no obstacle before it reached Mozgova, while it could envelop the left of the position by concentrating in the forest in front of the wing. In this way the retreat of the battalions left at Banja and Lukova might be cut off were they not to make a timely retreat. It would thus have been easy, if Alexinatz had fallen, to have captured Deligrad while pursuing the beaten army.

The commandant of Deligrad, the Engineer Colonel, Alexander Nikolich, had been a civil engineer. Beyond a scrap of paper, on which was roughly traced the space to be embraced by the defences of the position, he received no instructions nor orders of any kind on taking up his command, though these would have been of immense importance, seeing his unenterprising character. His staff comprised a lieutenant of infantry, a secretary, a commissary, and two orderlies ; he had, moreover, six two-horsed covered carriages, driven by their owners, some of them the richest and best of the *bourgeoisie* of Belgrade.

After the first battle of Alexinatz, Tchernaieff, named Colonel Jozo Gyorgyevich to command the troops at Deligrad. Two days after a commandant of artillery was appointed. This was a Russian colonel, very indolent, and generally little fit for active service, who, therefore, lived almost entirely in his quarters, leaving the Servian lieutenant-colonel of artillery, Wahofsky, to carry out all the duties connected with that arm. Nikolich and Gyorgyevich had frequent and violent quarrels every time there was a question of ordering new arrangements at Deligrad. While Nikolich, as commanding a special arm, executed or not, as he pleased, orders coming from Alexinatz which bore incontestable reference to that arm, he put on one side those given him by Gyorgyevich as being of a purely military character. This conduct was reciprocated, to the amusement of the members of the staff, who, a dozen times a day, heard from each of the two commandants, "That's none of my business!" ("*Cela n'est pas de mon ressort!*"*)

The battalions of the 1st and 2nd class of militia had been encamped for some days at Deligrad, but they had been hurried forward to Alexinatz, and the seven battalions of the 3rd class remained to carry out the works. They were armed with muzzle-loaders, nearly all useless, and the only officers were the *chefs de bataillon* and the company officers. There was no time for drill, as the men were employed the whole day on the defences.

The artillery in position consisted of—one battery of 12-pr. smooth-bores in the battery sweeping the Belgrade road; one battery of six-pr. smooth bores in the right battery of No. III.; two mortars, and two rifled mountain guns in Nos. I. and IV.; two mortars and two 6-pr. smooth-bores in No. V.; in No. VII. two rifled mountain guns and two 6-pr. smooth-bores; and two pieces of the latter calibre in No. VIII. The gunners were men of the 3rd class of militia. Lieut.-Colonel Wahofsky took charge of the distribution of the artillery, and completely filled all the magazines.

When we remember that throughout the war no instructions whatever were given to the Commandant of Deligrad relative to the defence of the position; that this Commandant was perfectly unfit for his duties; that no measures were ever taken, though often re-

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* *Sic* in original German text.

commended, to ascertain distances to serve as guides in laying the guns, it must be clear that had Alexinatz fallen and the Turks had vigorously pursued the beaten enemy, Deligrad must have fallen also. But the Turks, after nine days' fighting at Alexinatz, retired to the left bank of the Morava, and on the 1st September routed the Servians at Prejilovika.

The attack on Alexinatz, undertaken by the Turks with their whole forces in the last days of August, failed, and the Turkish commander-in-chief then conceived the idea of enveloping the town by the left bank of the Morava. After the 26th, some detachments crossed the river by a bridge thrown across at Bisimir and had reinforced the troops under Ali Saib Pasha to the south of Gitzovata. On the 1st September the greater part of their forces having passed over to the left bank attacked the Servians, 13 battalions and 4 batteries strong, at Prejilovika. The Servians were routed and driven back in the greatest disorder. On the 2nd, in consequence of this affair, Tchernaieff telegraphed an order to immediately fortify the heights of Djunis.

After the defeat just sustained, Tchernaieff and his chief of the staff, Komaroff, couched their despatches in the most laconic terms, without giving the slightest indication as to the object of the order nor the means of carrying it out. To any question on these points the stereotyped answer was sure to be—" You are officers, you therefore know what you have to do." Thus in carrying out these orders, everyone acted according to his own lights, as best he could, but without any general plan, and without being quite sure whether what he was doing answered the necessities of the case. Something was therefore done, as quickly as possible and without, at all events at first, attempting to divine the intentions of Tchernaieff. As, however, after the battle, the Turks had advanced their outposts on the hills of the left bank of the Morava, it was beyond all question that the order concerned the heights north of the Ljubes stream, in order by means of works to be constructed there, to keep the enemy at a safe distance from Deligrad till its entrenchments were in a fit state to resist him.

With this view a very superficial reconnaissance was made of the heights of Djunis, which were completely unknown and difficult to explore. No time was available for the far more searching reconnaissance which the case required. Not only was the reconnoitring officer alone, but he was also impeded by the duty of assembling workmen and tools. The order for the fortification of the heights made no provision for this duty, and Nikolich and Gyorgyevich, full of apprehensions for Deligrad, retained every reinforcement of men and material which arrived there, without the least heed as to the requirements of Djunis. And when this fact was reported to head-quarters, with a request to know from whence men and tools were to be obtained, if it were not intended that any should be sent from Alexinatz, either no answer at all would be returned, or one after this fashion. " We have enough to do ourselves, you must get through your own business as best you can."

Under these circumstances no works of fortification had been commenced during the day (the 2nd September), till the reconnoitring officer fortunately fell in with the brigadiers, Petrovich and Benitzky, who were collecting at St. Nestor the debris of their broken battalions flying from Prejilovica. About six p.m. also, two battalions were found at Vitkovatz, and were immediately led by the Russian Lieutenant of Engineers, Nicholas Nicolaieff to the pioneer barracks. Here having procured carts and tools, 700 men were led up to the heights, which they reached about eight o'clock, when they commenced work. It was arranged that in the first line simple shelter trenches with a ditch in front, should in the first instance be thrown up on the sites afterwards occupied by Nos. 1 and 2; they were to be strengthened and extended as opportunity offered. These points had been fixed upon, during the rapid reconnaissance of the position, as being the most favourable, and when the copses in front had been cut down, the view thence was open as far as Vitkovatz, and the plateau of Djunis itself could be perfectly swept by a heavy fire. It was not prudent to take the demoralised men to the extreme southern edge of the wood to work in the open, but, on the other hand, as there were no covering parties to protect the labourers, there was imminent danger of a surprise when working in the wood itself.

Tchernaieff with his chief of the staff, Komaroff and his assistant, Lieutenant-Colonel Monte Verdi, and with the Russian Lieutenant-Colonel of Engineers, Klemenko, arrived about nine p.m. from Alexinatz and immediately proceeded to inspect the position. Under the impression that the whole of the troops defeated on the 1st had assembled on the heights, their indignation was extreme when they found the workmen quite unprotected by covering parties. Not knowing the ground, and taking no steps to understand it, they immediately began to discuss the works to be executed. Komaroff wished to cover the whole heights with redoubts; Monte Verdi proposed others in addition, with a complete system of mines; Klemenko demonstrated the necessity of cutting down whole forests. The result, however, was that next morning three battalions were provided with tools and set to work, while three other battalions under Petrovich protected their labours. Benitzky returned to Deligrad where he was placed in charge of eight battalions.

All next day (the 3rd), and night, the work of entrenching the position was carried on. Two battalions executed the shelter trenches and an open work above Vitkovatz, the third cut openings through the woods. A road along the northern flank of the heights was traced down to the pioneer barracks. Four companies of pioneers arrived from Deligrad in the course of the afternoon, but they were exhausted with fatigue and were only employed in cutting the copses and clumps of timber in front of Nos. I. and II.

But in spite of the zeal displayed this day the works did not advance very quickly. It was difficult to keep the men, unaccustomed to discipline and labour, from absenting themselves in order to maraud or build themselves huts. At nightfall 1,364 yards of shelter trench had been thrown up, running from the open work above Vitkovatz to the first lunette towards Krevet, with intervals of various lengths, and traced so that its parts were mutually flanked. The entrenchment on the left for four guns and two companies was half completed by 300 men. It was an arc of three-fourths of a circumference, following the upper edge of the foot of the hill, which here formed a salient. The parapet was 8 feet 2 inches thick, and 4 feet 3 inches high at the crest; the earth was taken from an outer and interior ditch. The latter was arranged to give shelter to guns not in action and to form magazines. The guns were disposed to sweep the slopes in front, that towards Sregovatz, opposite the hill, and also to fire into the Morava Valley on the flank; they were mounted *en barbette*, having a parapet height of 3 feet.

The lunettes on the right were worked at during the night by the four companies of pioneers, 135 men strong, under the superintendence of Petrovich. They were to receive each half a battalion and four guns, they were traced before nightfall, and two were already profiled, when the enemy was seen to commence work on the opposite heights. He was suffered to work all night without interruption. Turkish troops were at the same time perceived on other points preparing to entrench themselves.

The lunette commenced on the extreme right was intended to cover a retreat in the direction of Krevet; its left face also aided the lunette in rear in sweeping the heights directly in front.

In the evening a strong detachment under the Lieutenant-Colonel of Engineers, Karadzich, joined the working parties on this flank, and when, the next day, the works were completed, they set about clearing the forest in front, and forming approaches to them.

Early on the 4th Tchernaieff arrived with his staff, and having rapidly examined the lines, appointed Lieutenant-Colonel Klemenko as commandant of the position of Djunis; he also fixed the armament, and gave directions that when it arrived, the guns should at once be turned on the enemy's working parties.

The approaches to the redoubts having been so far cleared that it was possible to bring their guns into them, although with great difficulty, two batteries of light pieces were placed at about two p.m. in the advanced lines of the work opposite Vitkovatz, and fire was opened on the enemy's working parties. This caused him to cease his operations, which afterwards were only carried on at night.

In the course of the day the works on the left were completed, the shelter trenches were converted into entrenchments, with a parapet 8 feet 2 inches thick. The two lunettes were completed during the following night, with a relief of 8 feet 2 inches, and a thickness of parapet of 13 inches.

On September 5th, after the completion of the openings cut through the woods, Klemenko gave the order for the construction of Nos. I. and II. The pioneers were to cut a road from St. Nestor to No. II., but it was at first so badly traced by the Servian Captain of Engineers, Magdalenich (just promoted to be Engineer-in-Chief to the army), that it had to be altered, to avoid the necessity of deep cuttings and embankments. The entrenchment above Djunis, of weak profile, (4 feet 3 inches high, and 8 feet 2 inches thickness of parapet), was to receive four guns.

Particular care was taken in the construction of the work on the left of No. II. since Klemenko had established his quarters there. Besides shelters for officers and men, there where four others for guns not in action, each for two guns. Separate magazines were constructed for Artillery and small arm ammunition. A traverse had been constructed in front of the palisaded gorge to protect the Commandant's quarters and his office ; a kitchen, cellar and cells, were afterwards added, and platforms were laid down for the guns, which were arranged on the left face and fired through embrasures. The relief of the work was 6 feet 6 inches on the Artillery portion, 4 feet 9 inches on the rest of the circuit. Two battalions of infantry and two companies of pioneers were employed here under Klemenko himself and a Russian Captain of Engineers. The redoubt was completed on the morning of the 7th, and occupied by two companies and four guns. The neighbouring work was garrisoned by a similar force.

The advanced works executed during the night of the 2nd-3rd September were as yet almost useless as a good defence to the position of Djunis. The line to be fortified was completely masked at this point, and orders were given to commence early the next morning to cut the trees on the flank.

About 10 o'clock in the evening Klemenko received a despatch from Tchernaieff, informing him that a battalion of volunteers and a company of Montenegrins under Major Peterson would make a night attack on the enemy at Dolni Ljubes, and that during the operation the troops on the Djunis position heights were to remain perfectly quiet in order not to betray their positions. With the most extraordinary disregard of this order, Klemenko at midnight ordered Petrovich to send a strong patrol immediately to communicate with Peterson and ascertain the time of his attack, and at that moment his three battalions were to raise a prodigious uproar, *(un vacarme effroyable)* but without firing and without quitting their positions. The order concluded with the direction that "*le tapage au moment du besoin devra être epouvantable.*"

Petrovich at first was inclined to ignore this order, which seemed to him to be impracticable, but finally he despatched the patrol. About 4 a.m., Peterson arrived with six Cossacks at Vitkovatz, having in the dark lost his battalion and the Montenegrins near St. Nestor. The night attack therefore failed.

As the work of clearing the ground in front of the first line and the demolition of St. Nestor progressed, the disposable workman were employed on No. III. situate on the culminating point of the heights. The right of this work was arranged so that the guns placed there brought a heavy fire on the slopes from No. I. and the Krujevatz road, while at the same they could easily destroy the palisaded gorges of the works in front. The relief of this part of the work was 3 feet. The left was organized entirely for infantry, and had a relief of 4 feet 2 inches, the parapet being 8 feet 2 inches thick. The very winding road on the northern slope of the plateau, entered this front at a right angle and continued from the salient of No. II. by a double curve to the openings cut in the forest.

On the 8th and 9th, two companies of pioneers were employed on shelter trenches uniting the lunettes, and they threw up on the open plateau below No. III., six emplacements for guns in a circular form, which were designated No. IV. These epâulments were executed by a Russian Captain of Engineers on the plan of the Austrian Lt. Col. of Engineers, Schraml, and their object was to sweep the valley of the Morava. They were, however, completely useless; the pieces had no need of any cover, as the plain could in no wise be seen from the plateau.

The abatis on the slope down to the river Ljubes were not completed till the 10th. It had not been possible to finish them before on account of the enterprises of the enemy's advanced posts, hidden in their shelter trenches only 1,100 yards in front. The cutting down of the trees and their transport to the site could therefore only be done at night.

From the preceding description it will be noticed that the fortification of the position was entirely on defensive principles. It is not known whether this was according to Tchernaieff's intention, but it is certain that Klemenko did nothing himself, and he was never seen outside No. II., in which work he had established his quarters.

On the 10th Klemenko was able to dispose of 12 battalions of infantry and three batteries without reckoning the pioneer companies. These troops were thus distributed:

Two companies and four guns in the entrenchments above Vitkovatz.

Two companies and four guns in the shelter trenches in front of that work.

Two battalions in the forest between that work and the lunette.

Two battalions in rear of the last as a support.

One battalion and eight guns, equally divided, garrisoned the two lunettes.

One and a half battalions occupied the communications between the lunettes; these troops watched the country and were also to maintain the communication with the troops on Mount Krevet.

Four companies garrisoned No. I. At first, two companies and four guns were told off for this work, but the guns were removed to the lunette on the extreme right, and two more companies substituted.

Two companies and six guns, garrisoned No. II.

Two companies outside the work formed its reserve.

One battalion in No. I., and one and a half battalions on the St. Nestor heights and in the convent, formed the general reserve.

On the 12th September, at 8 a.m., the people in No. II. perceived eight to ten Circassians preparing to pass through the village of Dolni Ljubes, Klemenko immediately opened fire on them, and 24 shots were fired; the Circassians regained their lines, but the village was in flames. Tchernaieff with all his staff hurried up from Deligrad, thinking the enemy had attacked in force; Klemenko, alarmed at Tchernaieff's furious approach, endeavoured to persuade the commandant of the artillery battery, to declare he was only trying the range, but before this little plan was arranged, Tchernaieff was on the spot, angrily demanding why the village had thus been bombarded. On learning the truth, the enraged commander-in-chief relieved Klemenko from his command, and ordered him to quit the field immediately for Belgrade.

The Russian Engineer Colonel, Medvedofsky, was appointed commandant in his place, and this officer was likewise placed in charge of the Deligrad-St. Nestor road and the bridge thrown over the Morava. A field telegraph was established along the road with stations at Deligrad, Djunis, and Krevet. Abatis were placed across the road in front of Vitkovatz.

On the 15th September Medvedofsky ordered bonnettes of the Austrian method to be placed on the parapet, as he had remarked the great number of men who had had the fingers of their left hands carried off, and he wished to ascertain whether or not this was the result of voluntary mutilation. These bonnettes had been perfectly successful at Alexinatz.

On the preceding day, the 14th, a skirmish had occurred in which the Servian artillery showed itself to advantage. An artillery duel, commenced by the Turks, was carried on at the left of the Servian position, and after a three hours cannonade was terminated by the complete destruction of the Turkish work above Srezovatz. Another artillery fight was carried on at the Servian right, lasting about two hours; the Turkish shells which did not burst produced no effect, those which penetrated the parapet only displacing a small quantity of earth. Two Turkish battalions attacked this part of the position with great bravery. Rushing from their shelter trenches they crossed the stream at the double under the fire of the lunettes, and reached in a completely exhausted state the belt of forest in front of the abatis. A part penetrated to the latter, but on discovering it at once turned about, carrying off the remainder with them, and were pursued by the Servians.

Having described the position of Djunis and its defences, it is now necessary to speak of the works executed about the same period at the position of Bobovitz, and which were rendered necessary by the movements of the Turks.

On the night of the 3rd and 4th several Turkish detachments crossed the Morava near Dolni Adrovatz, and entrenched themselves at the edge of the wood which exists there. On the 4th some Circassian detachments from Trujan attacked and occupied Bobovitz, which had been abandoned by its inhabitants since the 1st, and a party of their cavalry pushed forward to near Neritjef-Mehana, where they killed 17 men of the train, who were marching towards Alexinatz; this was about 10 o'clock in the morning.

Tchernaieff only heard of this incursion by the enemy on the right bank about noon. Major Peterson was at once directed to drive them back. The cavalry were driven over the river after setting fire to some farms in Bobovitz, but the troops entrenched in the wood held their ground under cover of a well sustained and well directed fire. Peterson, therefore, contented himself with occupying the village and posting his three battalions on its left, fronting the Morava, and remaining in constant readiness to march. Each battalion was to detail a company to reconnoitre towards Trujan, and some detachments of pioneers, which arrived in the course of the night from Deligrad and Alexinatz, set to work on the defences under the supervision of a Russian Engineer Officer. The western portion of the lines was first commenced, with two epaulments for guns and shelter trenches.

On the 5th another battalion of infantry arrived with tools, and they were employed on the shelter trenches for the advanced posts along the Morava from Deligrad to Bobovitz. The enemy then established batteries above Trujan, so that these works could only be carried on at night. The works in rear, however, were beyond the range of these batteries, and their construction as a second line of defence was continued, so that from the 5th to the 10th, work was concentrated all day on this line, and all night on the advanced shelter trenches and the batteries at Klövtschi and Jasenje. A redoubt for four guns and a battalion was thrown up at Neritjef-Mehana, which had been converted into a hospital, but it was very badly traced, its right face being directed against the wood of Klövtschi, only 430 yards distant, while the left face fronted perfectly impracticable ground. This redoubt had the usual profile, 6 feet 6 inches relief and 12 feet 6 inches thickness of parapet. It was provided with banquettes for musketry and platforms for the guns, and had an interior traverse and expense magazine, but no covered shelters for the garrison. Farther on, following the edge of the high ground, were shelter trenches and two batteries, to which, after the 11th September, a third was added, also with shelter trenches. The batteries of the left of this line fired obliquely to protect the left flank of Bobovitz; the flank batteries crossed their fire with those placed in front of the edge of the Jasenje wood.

Here a battery had been thrown up on the right bank of the stream of the same name. Thanks to its retired position it was completely sheltered from the fire of the opposite heights, and it took an active part in the combats after the 11th without being itself exposed to much risk. It was, however, different with the batteries at the edge of the Klövtschi wood; the ground in front was perfectly open, and they would be completely seen from the heights above Gorni Ljubes. They were directed against the Morava and Bobovitz to prevent the enemy from debouching thence, and to assure the flank of the position on that side.

Captain Tovarovitch, of the Artillery, who had placed his six heavy guns in the open battery immediately in front of Bobovitz, towards Alexinatz, experienced on the 8th and 9th immense losses in men and material from the fire of the enemy. He therefore decided upon constructing a blinded battery instead of a simple field work, and to place his wagons behind an epaulment. A detachment of pioneers made the gabions required, which were 3 feet 3 inches to 4 feet high; the gunners and infantry cut and brought up the timber. The parapet was made 13 feet thick, the height of genouillère 3 feet, the embrasures deep, and their cheeks revetted with gabions. A double row of beams, covered with 4 feet 10 inches of earth, rested upon traverses between the guns formed of two rows of gabions, and protected the battery against indirect fire from above. The platforms were sunk 1 foot 11 inches. This battery worked admirably the whole time it was in action, and only required repairs to the parapet when shells had burst in it.

The night parties working in front of Bobovitz at first confined themselves to strengthening the shelter trenches and to constructing about 300 rifle pits along the wood which follows the curve of the Morava at that point. About 500 other rifle pits were also formed on an arc of three-fourths of a circle, between the Morava and the ditch, half wet and half dry, along which the marsh in front of Bobovitz discharges its surplus water into the river. A trench, 6 feet 6 inches deep, united these rifle pits, most of which were at a considerable distance in front of the main works.

Dating from the 5th September minor skirmishes were a daily occurrence in front of Bobovitz, and small detachments of the enemy, taking advantage of the cover of the growing crops, constantly appeared at unexpected points. The Turkish artillery, also, on the opposite heights, did not cease from firing on the village at the rate of 15 to 20 shells an hour. The Servians under Peterson, now reinforced by a few battalions, contented themselves with merely repulsing these attacks; but on the 11th they advanced in force and drove the Turks from their positions, and compelled them to recross the river after a combat of four hours duration. In the following night, however, they again established a line of advanced posts on the right bank, and close to it. An attempt was also made by them to cross the river at the point where the marsh in front of Bobovitz drains into it, but this was repulsed by the batteries at Jasenje. The enemy selected this point as he could approach the river under cover of the high maize growing in the fields there.

This last attempt, which, if successful, would have necessitated the evacuation of the batteries in front of the wood of Klövtschi, induced Peterson to construct fougasses on the right flank of Bobovitz, an arrangement from which wonders were expected.

Between the 13th and 16th September the Turks succeeded in throwing a trestle bridge across the Morava, about 30 yards below the ford at Trujan, and having a width of 26 feet. This operation was executed without hindrance, and even without the knowledge of the Servian outposts, though only 1,100 yards distant; the latter were so harassed and fatigued that all they cared for was to be allowed to remain unmolested in their shelters. This apathy can not be wondered at when it is considered that since the 4th of the month they had worked night and day without cessation at the defences, and that no sooner had the works been completed than the men were sent into them to occupy and defend them without an interval of repose. The men occupying the rifle pits were worse off than the others, for though they were in comparative safety from the enemy's projectiles, they had no protection from the water resulting from the torrents of rain which fell. They also received their rations very irregularly. In spite of the complaints of their commander, the two battalions occupying these advanced rifle pits, some within 45 yards of the enemy's outpost, were retained in them without a single relief from the 8th to the 22nd September.

Before proceeding with the description of the remaining works executed at Deligrad after the 16th September, it will be useful to explain why the Turks did not profit by the victory of Prejilovika, when it would have been easy for them to follow the left bank of the Morava and seize Deligrad.

On the day of that battle the Turkish troops, commanded by Achmet Eyub and Ali Sahib, were deployed on a front of about five miles, the right wing resting on the river and the left on the upper course of the Gorni Ljubes stream (Ludak-Potok). During the preceding night their right captured by surprise some entrenchments held by the Servians, and their left was reinforced, which rendered it clear that their object was to throw back the Servians from the ford at Dolni Adrovatz, to seize it, and so intercept the communication with Alexinatz. This result was not attained, though they gained much ground on the left, and after the flying Servians had reached the entrenched camp of Veliki-Siljegovatz they ceased the pursuit, fearing for the safety of their left. The right wing was, however, pushed forward in the afternoon and next night to the school-house at Korman.

During the fight at Alexinatz, Tchernaieff had called up a portion of the army of the Ibar to Veliki-Siljegovatz to cover the approaches to Krujevatz, and to fortify the heights. On the 29th August he also detached some battalions from Alexinatz to reinforce these troops. But on the 1st September he seems to have completely forgotten the existence of these forces, and they took no part in that disaster. Tchernaieff and his staff, in fact, were greatly surprised that the Turks should attack on a Friday, that being with Mahommedans a holy day, and everyone at Alexinatz was still sleeping when at 8 a.m. a courier from Prejilovica dashed into the Court of the Konak (Government House), and spread a general alarm that all was lost. Tchernaieff immediately proceeded towards Prejilovika, and ordered up the Semendri brigade to reinforce the combatants, but the brigade only arrived in time to debouch from the tête-de-pont at Alexinatz exactly at the moment the artillery in full flight and hotly pursued by the Circassians, sought refuge there.

In spite of their success the Turks were in a critical position. According to their usual custom they had burnt all the farms and provisions, and in consequence of the bad state of the roads on the left bank of the Morava they could not be provisioned from the rear. It also became evident to them that if they continued their advance their left was threatened by the position of Veliki-Siljegovatz. They, therefore, in the evening ceased the pursuit, and entrenched themselves on the Morava from Prejilovika to Trujan, with their left nearly at Gredetin. They only advanced further towards the north as their works also were pushed forward, and this accounts for their tardy appearance before Dolni Ljubes and Krevet.

An armistice for 10 days was agreed upon between the Turkish and Servian Governments, to commence on the 17th October; but the fact was not at first known at the headquarters of the army, nor was it in point of fact observed. No measures were concerted between the commanders of the opposed armies relating to a line of demarkation between them, nor as to any of the numerous details necessary to be agreed upon. Peterson learnt it first at Bobovitz from a Turkish parliamentary, and conformed to it, permitting free inter-communication between the two sides within his command.

Tchernaieff only learnt the fact for the first time on the 20th on seeing three Turkish officers entering a café at Alexinatz. These, however, he made prisoners, and ordered Peterson and the other commanders to fire on any of the opposite side approaching their lines. In consequence of this order, also, many unsuccessful attempts were made by Russian volunteers against the Turkish bridge at Trujan, which was always found carefully guarded.

During the night of the 22nd and 23rd three Russian Engineer Officers offered to attempt the destruction of this bridge. They divided a weight of 56 lbs. of dynamite between them, enclosed in wooden cylinders. They certainly exploded their dynamite, but in a portion of the wood where they could not be seen, and returned to camp the following morning, declaring that the enterprise had been perfectly successful. Komaroff, to whom the report was made, refused, therefore, to credit the information brought him in the course of the day that the bridge was still perfect till it was explained to him that the Turks had thrown across the river a new bridge, precisely similar to that destroyed, and in exactly the same place! The bridge, in fact, was the original one, and had not been injured in the least.

The Turks made no complaints as to the total disregard of the armistice, but merely retaliated in kind, making nocturnal attacks, chiefly in the directions of Bobovitz and Krevet. Their artillery fired upon anyone crossing their front within range.

The Engineer-in-Chief, Magdalenich, was about this time superseded; nothing can be said in his favour as an engineer. His successor was Karadjitchs, a man addicted to strong potations, and nearly always lethargic from drink. In his clearer moments the orders he gave were very diffuse and hardly practicable. In consequence of his confused instructions relating to the defence of the road to Viekaschinovatz, the works for that purpose were constructed on the right instead of the left of the road, until altered by Doctoroff, who was now chief of the staff. The two lunettes shown in the plan were also nearly completed. The works towards Viekaschinovatz were intended to oppose a possible offensive movement by Gorni Ljubes.

Some of the reconnoitring parties sent out by Komaroff brought in a report that the Turks had thrown across another bridge below Gorni Ljubes, but the report was as false as that relating to the destruction of the Trujan bridge.

The defences established at this point followed the edge of the plateau, which here turns at a right angle; the most advanced work was a lunette with flanks, about 55 yards from the marshes there. It was defiladed from the heights on the opposite bank, and was only intended for infantry defence. Three batteries, supported by this lunette, were constructed in echelon as far as the village; some of their embrasures were oblique. Parallel to the road were two other batteries, with an entrenchment between them, with advanced shelter trenches. After the completion of these works they were included in the Deligrad position, and placed under the command of Alexander Nikolich.

After the construction of the works already enumerated for the positions of Deligrad, Djunis, and Krevet, no new ones were commenced, but those already executed were gradually improved. Shelter trenches and epaulments for artillery were added in front of No. XIII., and at Vitkovatz two companies formed a passage through the abatis in order to permit of an offensive movement, for Tchernaieff meditated a general attack on the enemy's positions on the 29th September. Some of the Krevet works were furiously cannonaded from the 13th to the 16th, preventing some proposed modifications from being carried out; they were, however, made ready for the 29th. No details exist of the works at Krevet and Veliki-Siljegovatz.

On the morning of the 29th the position of the contending armies was very strange. On the Servian side 39 battalions, under Horvatovich, were placed along the left bank of the Djuniska stream, on the entrenched heights from Velika-Siljegovatz to the stream, west of Kaonik. Benitzky's eight battalions were at Kaonik, on the heights to the right of the Djuniska; these battalions formed the communication between the Servian right and centre.

The centre was formed by the positions of Krevet and Djunis, the first held by Medjeninoff, the last by Medvedofsky; the total strength here was about 10,000 men.

On the right bank of the Morava 5,000 men with five batteries held the entrenchments from No. XIII. to Viekaschinovatz. The left, 30 battalions strong, under Jovan Popovich (the titular commander was General Constantine Protich, but he was never seen, and never troubled himself about his troops), held Bobovitz, Alexinatz, and Glogovica.

Tchernaieff had, therefore, more than 50,000 men in line between Veliki-Siljegovatz and Alexinatz, including all the reinforcements that had arrived from Russia.

The Turkish army, the front of which formed an acute angle towards the north, had its left wing at Radovatz in front of Veliki-Siljegovatz, and from thence its lines occupied the ground in front of the Servian centre; the right wing stretched from there partly into the plain of the Morava, and partly on the heights bounding that plain on the west as far as Tejica. The army was composed of the corps of Achmet Eyub and the five divisions of Ali Sahib, a total of 60,000 infantry, 2,500 cavalry, and about 18 batteries (108 guns). The Commander-in-Chief, Abdul Kerim Pasha, resided at Nisch, and rarely showed himself to the army. Detachments amounting to 5,000 men watched Alexinatz on the right bank of the Morava. At Nisch there was a reserve of 20,000 men with four field batteries, exclusive of the armament of the place.

Though Tchernaieff had fixed on the 29th for the general attack on the Turkish positions, it was not carried out as intended. The orders had been issued in the night of the 28th and 29th, but apparently some of the commanders did not receive them in time. Horvatovich, on the right, received the orders to attack at 5 a.m., and the troops at Bobovitz received theirs at 8 a.m.

The attack on the right was very vigorous, and the Russian battalions especially distinguished themselves in the assault on the entrenchments. Though the attack was insufficiently prepared by artillery, and the works were surrounded by three to four lines of shelter trenches, the Russians after a short fire rushed to the assault, and succeeded in reaching, after severe loss, the works. Then, in the majority of cases, a hand-to-hand fight ensued. The Turks, who up to that moment had remained quietly in their shelter trenches firing on the approaching enemy, precipitated themselves upon him, and either drove him back or were compelled to retreat to the lines of shelter trenches in rear of the works, and under the protection of their fire. In this latter case the assailants did not pursue them, but threw themselves into the ditch to recover breath and to regain their formation. They then attempted to scale the parapets, but the Turks mounted the superior slope and repulsed the assailants with the bayonet. However, the latter could not be denied, but entered the work, the garrison fled, and only in one instance, in front of Krevet, did the Turks continue to contest the possession of the work after the enemy had penetrated into the interior.

The assaulting troops were preceded by strong firing parties on the right and left of the line of advance to the point chosen for attack. The men in the firing line nearest to this point joined the assaulting column, and took part in the struggle before the work, and in its occupation if carried; those more distant continued their fire rapidly against the work and the defenders of the shelter trenches in front up to the last moment. The distance through which the assaulting columns advanced at the charge was usually more than 325 yards; the firing line ceased its fire when the hand-tc-hand combat took place, and recommenced when the defenders fled or the assailants were repulsed; when the assaulting column entered the ditch the firing line kept up a violent fire to prevent the defenders mounting the superior slope. At some points the assault was made with greater care and precaution, and this was always the case when the assaulting battalions were well provided with officers; thus, while before Gredetin, there were scarcely two officers to a battalion, the Russian troops had six and even ten officers to a battalion, besides many effective and experienced non-commissioned officers.

Medvedofsky, after a preparatory artillery combat, led his troops to the assault of the heights above Dolni Ljubes, his right wing during the advance keeping up a well sustained artillery fire. He was able to reach, almost without check, the demolished Turkish work, but having passed the wooded slope of the Sregovatz hills, at the moment he attempted to continue the advance, he was received with a murderous fire of artillery and musketry. The Turks held the wood in rear of their entrenched front with a few battalions and two guns, where they awaited the moment when Medvedofsky, advancing in the open, would feel the full effect of their fire.

Medvedofsky's four battalions were terribly cut up, and retreated rapidly and in disorder to their positions in rear of Dolni Ljubes.

The Servian left wing at Bobovitz and Alexinatz which had received the order to attack at 3 and 8.30 a.m., respectively, merely cannonaded the position in front. The infantry did not attack, for the enemy had for some time been solidly entrenched, and showed no disposition to quit his lines.

At nightfall Tchernaieff was compelled to recognise that his design had failed. The troops had suffered severe losses, and even the points captured could not be held. He accordingly ordered the army to fall back into its positions. The next day, the 30th, the Turks brought up a superior force of artillery and established themselves solidly, except near Kaonik, along the Djuniska in front of Horvatovich.

Between the 1st and 19th October the two adversaries remained facing one another. The Turks entrenched themselves on the ground won by them in front of Veliki-Siljegovatz, and the Servians prepared a position of retreat in rear at Mali-Siljegovatz. The Turks also brought up reinforcements from Nisch.

On the 19th October, a fatal day for the Servians, the Turkish commander ordered a general attack, although the rain which had set in at the beginning of the month came down heavily. At dawn the right wing, composed of Fazil Pasha's division, opened a heavy fire from the heights on the left bank of the Morava, on Alexinatz and Bobovitz. The division under Hafiz Pasha opened against the Krevet-Djunis line so fierce an artillery fire that Tchernaieff and his staff for a long time thought the principal attack would be made here ; he accordingly brought up to this point his small reserve from Deligrad, and remained himself at Krevet all the afternoon.

But this was not the principal attack, which was made by the Turkish left under Suleiman and Aziz Pashas. While Fazil and Hafiz kept up their cannonade, Suleiman, leaving Aziz to engage the front of Veliki-Siljegovatz, moved against the extreme right of Horvatovich, crossed the Djuniska, drove back the outposts, and reached at the same time with them the most advanced Servian works. Here the combat began about 11 a.m., and was continued with varied success, but the Turks were determined to win these important entrenchments. After two unsuccessful assaults, during which they were exposed to the flank fire of the lateral works, they desisted and opened a fire from their artillery. The Servians immediately abandoned the entrenchments of the whole of this front, and the Turks at once occupied them.

Suleiman now drove the extreme right back upon Mali-Siljegovatz and about two p.m. effected a junction with Aziz, who had also obtained some success. The united troops then drove back the remainder of Horvatovich's command on Mali-Siljegovatz, and leaving a brigade to follow them up descended the valley of the Djuniska, occupying its two slopes to within $1\frac{1}{2}$ miles of Kaonik.

Hafiz Pasha, in position between the Djuniska and the hills above Sregovatz, had not deployed any considerable force against Kaonik, which, however, was the natural objective of his infantry. On the Morava the cannonade continued all day, varied by false attacks, undertaken here and there by the Turks.

It may be mentioned that during the attack on Veliki-Siljegovatz some fougasses were exploded on the flanks, which had the effect of arresting for some time the advance of Aziz Pasha. They had been arranged by Professor Klerich, who had ignited them himself with the apparatus used in the Austrian army, and which the Russian officers at Bobovitz had pronounced impracticable.

The success gained by the Turks on this day was important. They had forced a way out of an acute angle in which they had been previously shut up. They gained a real front towards the north, and were able to advance their right from Dolni Adrovatz to Tejica, from whence they could effectually observe the Valley of the Morava.

After the battle the Servians occupied the following lines:—Horvatovich was at Mali-Siljegovatz, fronting towards the south, having established his junction with the centre by Crkvina and Kaonik. The rest of the line was as before.

Unimportant skirmishes took place till the 29th October, but the Turks succeeded in capturing a hill before Crkvina, commanding the Valley of the Djuniska, and in fortifying it. The Servians built several hospitals at Deligrad, and Professor Klerich with his own hand mined the road to the west of the pioneer barracks. The relations between the Servians and the Russians had become very strained and bitter, and they would not act together. It was under these circumstances that the 29th October, the decisive day of the campaign arrived. It is not possible to give precise details of the strength of the army on that day, as commencing on the 19th, numerous furloughs were accorded to officers and men, and even those who could not obtain leave from the superior authority got them from their immediate chiefs, who for three ducats gave a fortnight's leave, and for three more an extension of another fortnight. From this it may be judged whether the officers who remained and commanded troops so demoralised felt much eagerness and ardour on the eventful day.

The Turkish forces were thus disposed. On the right, Fazil Pasha with 12,000 men, four field batteries, and some guns of position. Suleiman and Hafiz with 20,000 men, 30 guns, and a strong detachment of cavalry and infantry, with the two batteries in the entrenchments of Gorni Ljubes. The reserves from Nisch, under Adil and Jadiah Pashas, with 15 squadrons, were at Veliki-Siljegovatz.

About eight a.m. the Turkish batteries opened fire all along their line, directed especially against Krevet. Before Alexinatz the combat for the whole day was one of artillery only, but some infantry fights took place at Bobovitz, and Fazyl Pasha made demonstrations about Prejilovika, Trujan and Bisimir as if he intended to cross the river at those points.

The principal attack was, however, against the north front, where the Servians, surprised by the Turkish fire, only began to reply about 8.30 a.m. The Turkish artillery continued the cannonade incessantly till 11 a.m.

At that hour a column of Suleiman's division advanced by the Srezovatz Valley and down the outposts to Vitkovatz. Another column moved along the northern foot of the Srezovatz heights, directly against the entrenchments on the left of the Servian centre, but before this column had, after deploying, reached the abatis in front, the defenders turned and fled towards the St. Nestor bridge. But at Vitkovatz they were received with a salvo by the first column which had captured the works there and were charged by the Circassians. These three battalions entirely owed their escape from total annihilation to the assistance of Lieutenant Klener of the Artillery, who brought two guns from Jabukovatz to the Morava near the bridge of St. Nestor (which by this time was demolished), and with a few rounds of well-directed grape forced the Circassians to retreat.

The guns above Vitkovatz were withdrawn in time, and took position in the entrenchments in rear of Djunis.

The two Turkish columns having seized the heights above Vitkovatz, re-formed their detachments scattered through the wooded scene of action, and remained there till the assault on Krevet was commenced.

Near Krevet the Turks fell on the first line of entrenchments, drove out the defenders, and seized the works nearest Kaonik. This latter position was commanded by these works, which also enfiladed the trenches uniting them with Krevet. The Turks drove the Russians out of these trenches.

The Servians now gave way everywhere, and at two p.m. their centre was in full retreat towards the bridge at the pioneer barracks. The flying troops were only preserved from complete disaster by the opportune explosion of six fougasses placed on each side of the Krujevatz road, which checked the pursuit of the Turkish squadrons coming from Djunis. The Servians were then able to retreat across the bridge without further molestation.

The bridge was demolished and the pioneer barrack set on fire. In the evening Tchernaieff ordered the evacuation of Alexinatz and Bobovitz, which the Turks occupied on the evening of the 30th.

On the 1st November, the armistice so eagerly desired by the Servians and Russians was agreed upon.

C.W.

# PAPER IV.

# REPORT ON BLASTING OPERATIONS AT MOUNT SILOSO, SINGAPORE.

BY LIEUT. H. E. McCALLUM, R.E.

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*Communicated by the Inspector General of Fortifications.*

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MOUNT SILOSO is the most westerly feature of the island of Blakan Mati, which covers the new harbour, and forms the southern side of the entrance thereto. It consists of a narrow ridge about 150 yards in length, falling at a gradient of one in nine in a N.W. direction, and on which the new battery is now being constructed. Beyond this ridge is a narrow neck of ground communicating with a tongue of very limited dimensions, bounded by the cliffs, and at a height of 115 feet above sea level.

This tongue makes an inconvenient dead angle at the very entrance of the harbour, as it screens from view a portion of the submarine mining field designed for this position and the immediate front thereof, which it is one object of one 7-inch and two 64-pounders to sweep.

The view in *Plate* I. is taken from the site of the right hand 64-

pounder barbette emplacement, and shows the entrance into the new harbour, and the knoll which is the subject of this report. I determined to remove this knoll and make a glacis, which could be swept by the fire of the guns, but to do this required much labour and expense, as a great portion of the ground appeared to be of a hard rocky nature.

I, however, ascertained that there was a large quantity of powder in store, manufactured in Madras before the time of the transfer of the colony from the Indian Government. This powder had been condemned as unserviceable, and classed as No. IV. and No. VI., and I considered, therefore, that the best and cheapest way to get rid of the tongue would be to fire a series of mines, which would blow a portion of the knoll into the sea, and so loosen and shake the rock within the horizontal radius of rupture that it could be removed by coolie labour at economical rates. A quantity of new powder was arriving in connection with the defence of Singapore, and as magazine room was valuable, I had no difficulty in obtaining the sanction of the officer commanding to expend an amount of the condemned powder, which was estimated at 19,000 lbs., on the proposed service.

The general nature of the project was to fix a series of charges at levels, coinciding with the maximum angle of depression of the guns, which for the 64-pounders was six feet higher than that of the right hand 7-inch gun. The charges were then to be exploded simultaneously, and a quantity of spoil afterwards removed by coolie labour commensurate with the funds available.

With this view it was proposed to spring ten mines, the estimated craters of eight of which are shown on *Plate* II. Two small mines, I and J (not shown on the plan, but will be described in detail hereafter), were sprung at an early stage of the operations to test the power of the condemned powder for blasting purposes. These charges were fired as common mines in easy ground and gave full craters. From an inspection of *Plate* II., it will be observed that mines A, B, C, D, G, and H fringe the cliff which runs along the south side.

These mines it was intended should blow seaward, so as to guard against the danger of spoil flying into the entrance of the harbour, whilst mines E and F, from their positions, were also calculated to blow in the same direction.

## Dimensions and Details of Mines.

| No. | L L R | Calculated radius. | Charge. | | Side of each box in ins. |
|---|---|---|---|---|---|
| | | | Calculated lbs. | Actual 90lb. barrels used. | |
| A | 26′ | 30′ | 2440 | 27 | 42 |
| B | 33′ | 36′ | 4474 | 50 | 52 |
| C | 31′ | 31′ | 2980 | 33 | 45 |
| D | 23′ | 23′ | 1216 | 13½ | 34 |
| E | 26′ 9″ | 26′ 9″ | 1914 | 21 | 39 |
| F | 27′ 9″ | 27′ 9″ | 2137 | 23½ | 40 |
| G | 20′ | 20′ | 800 | 9 | 29 |
| H | 21′ | 21′ | 926 | 10½ | 31 |
| I | 11′ 3″ | 11′ 3″ | 143 | 1½ | 17 |
| J | 10′ 3″ | 10′ 3″ | 108 | 1¼ | 15 |

To reach mines A and B, a gallery 43 feet in length was driven from the face of the cliff, with an oblique branch gallery to B, 48 feet long, and another to A, 39 feet long.

These were the first galleries driven; they were 5 feet high and 3 feet wide, as the Chinese coolies insisted that they could not bore through the syenitic granite in galleries of smaller dimensions. As it was, progress was very slow, the men engaged suffering much from sickness.

The syenitic granite, although it broke up when exposed to the sun and rain, was very tough in situ, and small charges of gun-cotton, which were exploded in holes bored from the face, had but little local shattering effect.

The other galleries fortunately were driven through firm, though not hard ground, and were of smaller dimensions, viz., 4 feet 3 inches high, and 2 feet 3 inches wide. Sheeting was required nowhere but for the shafts. These were three in number; one 27 feet 6 inches deep, communicating with mine C by gallery 15 feet long, and branch 10 feet long, and with mine D by gallery

26 feet long, and branch 9 feet long. Another, 25 feet in depth, communicated with mines E and F by gallery 22 feet long, and branches 24 and 21 feet long, and with mines G and H by gallery 15 feet long, and branches 10 feet and 17 feet long.

The third, 13 feet 6 inches deep, communicated with mines I and J by gallery 12 feet long, and branches 10 feet and 12 feet long respectively.

The chambers were formed in returns from the branch galleries, and were large enough to receive wooden boxes of the size required. These boxes were well tarred inside and out, and coated inside with a mixture of tallow, pitch, and beeswax, applied hot.

The gallery was increased in size at the end and chamber, so as to provide more room for loading operations.

Each 90-lb. barrel was emptied into two stout gunny bags, which were fastened with a piece of rattan, tied with a slip knot for easy manipulation in the dark. The whole charge being ready, the bags of powder were passed to the entrance of the gallery; half the charge was then passed along the gallery to the officer at the end, who emptied the powder into the box standing therein, in the case of the large charges, and breaking up the large lumps of caked powder. The empty bags were kept together, mouths up, until the operation was completed, and then passed out, so as to avoid any chance of there being a train of powder along the bottom of the gallery.

The carelessness of Chinese coolies made this, and other additional precautions, essential.

Two No. 12 low tension submarine mining fuzes were then fixed in each charge, and from each fuze diverged pieces of perforated hollow bamboo, the object of which was to provide a passage for the flame and means of igniting the charge in several places instead of two, thus accelerating the combustion of the whole.

The insulated wires were then brought along the side of the gallery and carefully covered by a row of rice bags filled with sand. The loading was then completed and the lid of the box put on.

The tamping throughout consisted of mat rice-bags filled with earth and well beaten with mallets.

The galleries leading to A and B mines were nearly tamped up before the loading operations commenced, a passage being left only sufficiently wide to take in the powder.

The mines were fired by divided circuit; mines, E, F, G, and H being in one branch, and A, B, C, and D on the other. A return wire was employed, and the resistance of the circuit was tested every hour with small test cell and astatic galvanometer whilst the tamping was being done.

The mines were fired with 100 Leclanché cells, which the Superintendent Submarine Mining had previously made up to ascertain whether they had been damaged during passage from England.

The result of the explosion is shown on *Plate* II.; the actual craters are shown by shading.

Mines A and B blew more towards the harbour than was anticipated, and C, E, and F more towards the sea, whilst G and H blew entirely seawards.

These results, together with the facts that whilst the galleries to A and B were driven through rock, the chambers had reached softer ground, and that the chambers for C and F were excavated in rock, lead me to the conclusion that only the centre of the ridge consists of rock, whilst on either side we find firm ground much more easily removable. Thus it was that the mines blew in a direction away from the ridge, and that the overlapping of craters B and C did not take place as was intended. A large quantity of earth was however displaced, and the whole mass much shaken and shattered. Thus in mines A and B, of which I enclose a photograph, a quantity of spoil, estimated at 3,500 tons, has been thrown down the cliff, being at the rate of about half a ton for every pound of powder.

A large body of coolies are now clearing away the loose spoil and opening up the front.

H.E.McC.

*Singapore*, 10*th April*, 1879.

# PAPER V.

# A PERMANENT STANDARD CELL.

By Major R. Y. Armstrong, R.E.

The following paper was read before the Physical Society on the 8th November, 1879.

The following description of a very simple standard cell of nearly unlimited endurance, and not likely to be injured by accident, may be interesting to those who cannot conveniently procure the more accurate standards now made.

It can be made by a novice without difficulty, and gives, when used with an electrometer, results within one per cent. of the truth.

In two porcelain or earthenware chambers, separated from each other by a *non*-porous partition, are placed the zinc and copper elements respectively. A semi-saturated solution of sulphate of zinc is poured into the compartment containing the zinc element, and a saturated solution of sulphate of copper is poured into the other.

The cell may remain in this condition apparently for years without undergoing any change: it is merely necessary to add distilled water to the solutions from time to time, as their level falls through evaporation, and to prevent the sulphate of copper from creeping up the sides of the cell.

When it is desired to use the cell as a standard, a string of cotton or twine is dipped in water and used to connect the liquids, which are thus connected electrically, but do not mix for hours. At the conclusion of the experiment, the string is removed and thrown away and a fresh one used next day.

After employing some of these cells for a couple of years no trace of copper could be detected in the zinc cell.

The electromotive force varies under conditions which I have not determined from 1·083 to 1·065 ohms; that is only 0·83 per cent.

from the mean value of 1·074. It is unaffected by raising the temperature to boiling point; and I have not observed that action of light produces any alteration.

A number of these cells when first made up were within an extreme range of 1·069 to 1·077 ohms.

It is probably desirable to employ commercially pure metals and salts, although I have not found that cells prepared with the above precautions differ in any way from those made up with ordinary commercial materials.

As I have already stated, this is not in its present condition an accurate standard, but it is a very convenient one for work not requiring greater accuracy than can be obtained by its means, especially if it can be checked at starting by some recognized standard.

R.Y.A.

14*th November*, 1879.

This cell may be used with a potentiometer (see *S.M.E. Notes*, pages 12 and 13) provided that a reflecting galvanometer be employed with a connecting key, and that the contacts be made as short as possible until the resistances have been so adjusted that there will be no deflection of the galvanometer on a more prolonged contact being made.

The results obtained with a condenser are not very accurate, as even the current required to fill a capacity of about $\frac{1}{3}$ microfarad appears to lower the E M F of the cell at the moment about 2 %.

N.B.—From experiments made during the past two months I think that the value of 1·07 volts will not differ more than 0·5 % from the correct value. The previous experiments were made with a zinc wire soldered to the zinc element and a copper wire to the copper element, and the variations made have been caused to some extent by damp at the junction of the copper lead with the permanent zinc wire; at any rate, since a copper wire was *soldered* to the zinc element the E M F has only varied from 1·065 to 1·075 volts. The mean value of which is 1·07 volts, which should be taken as the actual value.

R.Y.A

# PAPER VI.

## SOME NOTES ON

# MILITARY ENGINEERING INCIDENTS,

## IN THE WAR OF 1877-8.

By Brevet Major T. Fraser, R.E.

Although the art of the Engineer is as old as that of war, still civilized wars, if the humanitarians will permit us so to call them, are those in which engineering, in all its branches, has most scope for action. Each new invention of science now readily finds its place in such wars ; and electricity, steam and the modern explosives rank with gunpowder as recognised military agents.

In the American War of 1862-4, the stock of military knowledge with which the combatants started was small almost beyond precedent, while, at the same time, the habit of struggling with the greatest physical difficulties, in a country alike new and gigantic, had developed to the highest degree readiness to grapple with the most difficult engineering questions. Accordingly, while the handling of troops was often of the rudest and, by its slowness, gave constant scope for the use of field works, the movements of the opposing forces were, all things considered, facilitated in a way seldom, if ever, seen even in Europe. The great estuaries also, embraced in the theatre of war, permitted the co-operation of war ships, and gave a field for the newly invented methods of sub-marine mining. The seven weeks' war of 1866, was peculiarly barren of engineering features, but the novelty of having designed and prepared the materials for the repair of particular bridges, which it was expected the enemy would destroy in his own country, was for the first time introduced. On the other hand, in the war of 1870-1, although the field for naval action was limited by the use of torpedoes, the security of the German ports was almost entirely due to this branch of engineering: because, at that time their artillery defences were only hastily improvised, and were most feeble. This sense of security, in its turn, permitted the invader to withdraw and use great numbers of troops that, under the old conditions, must have been retained to guard against a naval counter attack, which the superiority of the French marine made not impossible. Again the perfection of the communications in France, depending as they do for their working on numerous artificial features, made these communications peculiarly open to destruction and repair: while the numerous rivers that came into play, gave additional scope for the work of bridging. The great number of sieges also that had to be undertaken, and the phase of investments into which the war latterly drifted, led to the execution of very extensive field and siege works.

In the war of 1877, small vessels had, on the Danube, a field not inferior to that furnished by some of the American rivers; while as in 1870, the naval inferiority of the invader drove him to protect his ports by the defensive means already referred to. In 1870 and 1877 the defender in each case had the better infantry arm: while, unlike the French, the Turks were superior in the material of their artillery. On the other hand, while in the wars of 1862-4, 1866, and 1870-1, the communications in the theatres of war were among the most perfect existing, it would hardly be possible, anywhere in the uncivilized world, to find a less developed country in this respect than Turkey, if we except the two railways, and a few paved chaussées, blessed, at intervals few and far between, with monumental remains of the Byzantine Empire in the shape of good stone bridges.* Hence, though there was ample field for the improvement of communications, there was much less scope for the demolition and repair of artificial features. At the same time it would be very much easier, in dealing with this war, to show what military engineering failed to do than what it actually accomplished, and this is due, in a great measure, to the imperfection of the means, namely, the inferiority or lack of technical troops.

In Russia there were, in 1877, eleven battalions† of sappers, and six half-battalions of pontooners, making a total force of about 14,000 men. The officering of the force labours, however, under several disabilities.

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* The bridge at Demotica, for instance, with its 30 arches. The Tchekmedje and Silivri bridges, and the bridge at Biela, on the Jantra.

† Each battalion consists of 26 officers, 2 cadets and 988 rank and file. Each half-battalion of pontooners carries 700 feet of bridge.

First, because the engineering requirements of the country have far outstripped the supply of men at all fit to conduct the Public Works, and consequently, the officers of Engineers, as they are trained, are to a great extent absorbed by the Government for such duties. The result of this appears to be a tendency not to fill up their places in what we would call the Corps, and to limit too much the supply of officers with the troops.

Secondly, there appears to have been, before the war, as with the Germans in the wars of 1866 and 1870-71, a want of that tactical union and co-operation between the Engineer and other services which alone fits the former for its duties in war, and familiarizes the Brigade and Divisional leaders with the advantage of its employment.

Third, the Engineer service, as in Germany, is looked down upon, and the best men would rather be out of it: nor is this surprising in a branch of the army in which, as compared with others, a higher educational standard is maintained, and harder work is necessary in peace and war; while at the same time the prizes to be gained are fewer and inferior.

In Turkey the Engineer service was free from these difficulties, for the simple reason that there was none. To this fact is due, to some extent, the Turkish unfitness for rapid movements, and in a great measure their inability to retard those of their enemy.

To this, too, may be ascribed the imperfection of their fortress defences, and the unreliability of their telegraphic and submarine mining arrangements. For these services, to the extent they went, they were dependent on Europeans, who, whatever their ability, were generally very much wanting both in the training and in the practical experience that, according to our ideas, is necessary for the proper performance of such duties.*

It is proposed to consider the subject under the following heads viz :—

1. Topography.
2. Submarine Mining.
3. Telegraphy and Signalling.
4. Communications.
5. Hutting, &c.
6. Fortresses.
7. Siege works.

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* We must except of course the railway workmen who, when they could be caught and persuaded to go forward, did the work of repair very well.

## 1. Topography.

On the subject of Topography there is not much to be said. The Turks, with the exception of a few officers of European education, hardly know what a map is. In Europe the staff, on both sides, used the Austrian staff map of about 5 miles to the inch, which though too small to give an idea of the ground, is fairly accurate as to the position of the villages, which are the chief landmarks, and as to the direction of the tracks such as they are.

The Russians, on reaching Bulgaria, at once employed their staff in improving this map, and had corrected sheets on bank post paper, printed at Bucharest, and issued for use. There was, as far as the Danube is concerned, an excellent map used by the International Commission, and this of course was in the hands of the invaders. In Asia, the Russians had a good general map, which the Turks reproduced, but only in time to supply them to their general staff just before Moukhtar's final defeat. Of special surveys hardly any were made, but a fair one of the ground round Plevna was sketched by a Russo-Roumanian party. The Turks had a "Chinese landscape" of the Tchekmedje-Derkos positions by which they, in part, laid out the works, and by which, as far as one can judge, they were a good deal misled. Plans of the works round Erzeroum were found on the person of a Russian officer, who had previously been employed in the Russian Consulate for some years, and the Russian information about Kars and Ardahan, was fairly accurate. On the whole, however, this branch of engineering had unusually slight influence on the campaign.

## 2. Submarine Mining.

The use of offensive torpedoes was confined almost entirely to the Russians, because their own ships were, with few exceptions, permanently stowed away in their defended ports, and were therefore secured from such enterprises. The only exception was the skirmish, on the 30th June, between a small Turkish gunboat on the Danube and four Russian torpedo boats: in this case the gunboat put out, but did not use, some spar torpedoes.

The Russian torpedo boats, on the Danube, appear to have been wanting both in speed and noiselessness. Still, on the night of the 25th May, two of them each managed to explode a spar torpedo under the "*Siefe*," causing her to sink.

These torpedoes, which were on 30 foot poles, appear to have been charged with dynamite and had a percussion arrangement, and also an automatic electric closing circuit, with a small battery in the vessel. The first was exploded by percussion; the latter by electricity, at the moment it was judged the charge was far enough under the ship. These boats had to steam up against the current, and advanced slowly against four Turkish vessels.

A similar attempt was made from Odessa, against the Turkish fleet off Sulina. The torpedo boats were brought out by a steamer to within some miles of the fleet; but the Turks were protected by a network of jute cables, which floated on the surface, being supported at intervals by ships boats. A torpedo boat closed with the "*Idjalic*," and fired a torpedo near her, but having got foul of the cables she failed to strike, and with difficulty got clear. The other boats did not close.

On the 12th and 13th May, a Russian vessel made an attempt with a towed torpedo against the Turks, but the working of the system completely failed. Next, on the 27th December, an attempt against the Turkish ironclads, in Batoum, was made. The Russians came round the lighthouse spit, from West to East, and from the configuration of the land, they were able to approach within a few hundred yards of the Turkish ships, at which they then discharged two Whitehead torpedoes. From ignorance these were not properly set, and ran along the surface till they reached the shore, where they were picked up unburst. To the offensive torpedoes used, therefore, only one success is due, and that was with the spar torpedo. The moral effect, however, of the sinking of the "*Siefe*" was considerable, and no doubt paralized the action of the Turks, both in the Danube and in the Black Sea.

With defensive torpedoes the only positive result was the sinking of the "*Sulina*," a small gunboat which was blown up by a contact mine, in the Sulina branch of the Danube.

The Russians with a view to draw the Turkish ships into a torpedo ambuscade, laid a number of contact mines in the Danube, about 6 miles below Toulcha; these were in galvanized wrought iron cases, pear-shaped, and fitted with an electric arrangement for firing by "observation," and also a contact arrangement, with lead ball and glass tube, containing bichromate of potash. The charges, of about 76lbs., consisted of guncotton discs, made hexagonal for stowage, with sides of about $1\frac{1}{2}$ inches, and a thickness of

$1\frac{1}{4}$ inches. The "*Sulina*" was misled by the immunity of other boats of less draught than herself; but although this is the sole instance in which a ship actually suffered injury, the employment of defensive torpedoes was very extensive, and the deterrent effects considerable.

On the Danube alone, the Russians made considerable use of them in connection with bridging operations, and in one instance torpedoes, or rather fougasses, were used by the Turks to bar the narrow sandspit which forms the approach to Sulina, and this led to a curious form of countermining; for when the place was attacked by a Russo-Bulgarian force, they attempted to drive a number of horses before them, so as to explode the mines. At the first Turkish shell, however, the horses "struck," and declined the scientific part intended for them.

The Turks also employed torpedoes in the harbour of Batoum; here they had a miscellaneous arrangement of mines of large size charged with powder, and small mines charged with guncotton; both kinds were "surface mines," and intended both for contact and observation. The flat sandspit, which forms the harbour of Batoum, has been thrown up by the Chorok river against the precipitous coast line of the Adjara mountains, consequently the water deepens very quickly near the shore, and attains an enormous depth close to land, hence, even with much more perfect arrangement, torpedoes alone would have formed an inefficient defence. The only lesson that was learned, in this case, is the great rapidity with which, even well armoured electric cables, are worn by the action of the sea on an exposed shingle beach.*

The Turks made a further use of torpedoes in the Narrows of the Dardanelles, the wires being taken into a certain fort, which forms one of the principle defences. The nature of these mines was kept a secret. On the "*Omne Ignotum*" principle it was perhaps as well.

Being, however, masters of the sea, they had small need of torpedoes, the Russians, on the other hand, undoubtedly used them in many cases, and were credited with having used them still more than they did. At Poti some small attempt was made, but the open roadstead was unfavourable to their employment. In the northern Black Sea ports, viz: Kirch, Sebastopol, Odessa, &c.,

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* This fact is well known to telegraph cable engineers, and shore ends are therefore made very strong, and landing places for them selected with great care.—Ed.

something more was done, and in piloting in ships, a great show was made of having to avoid the mines. Still, such as they were, they produced no little moral effect.

Defensive torpedoes in the Danube and its affluents, also played an important part. To begin with, the extreme importance of securing the great railway communication across the Pruth and the Sereth bridge, led, before the war, to the making of every preparation for forming a torpedo column, and to the laying of a system of torpedoes at the mouths of both these rivers. Again, to cover the passage at Simnitza, and by way of preventing interference on the part of the Turkish gun boats, the Danube was torpedoed at Parapanu, 10 miles West of Rustchuk. The Turkish gunboats made no exertions, at the time, to stop the work, which was not however very efficient, as, after the passage at Sistova, a gunboat went through the line of torpedoes and, as already mentioned, had an engagement with torpedo launches.

On the whole it may be said, that, while the positive results of torpedo warfare in 1877 are not more and, perhaps, less remarkable than in the war of 1862-4, still the consciousness of exposure to offensive torpedoes, pressed heavily on the dominant navy, and the difficulty of dealing with the unknown, in the shape of submerged mines, combined with coast artillery, has undoubtedly discouraged the attack, and greatly added to the security of ports.

### 3. Telegraphy and Signalling.

In the matter of telegraphs, Turkey is better off than in other respects. There was consequently no great scope for the making of any long lines. The Turkish armies in the field were entirely dependent on the civil staff of the existing lines; small parties of these, each with a few bullock arabas, and some ordinary bare telegraph wire and insulators, followed the movements of the troops, relying, not unsuccessfully, on being able to find the necessary poles as they moved through the country. They had no reeling-out apparatus, nor any of the appliances we think necessary for rapid work; hence their rate of laying was only about 4 or 5 miles a day. In the case of an action the line was generally available on the day following. One result telegraphy produced was generally pernicious, namely, it enabled the Seraskeriate to be constantly "conversing" with the general, a process that did not appear to promote *decision*.

The Turks attended fairly well to the connection by telegraph of the numerous advanced works they made round the fortresses, just before or during the war.

The fact, however, that these lines were "air lines" would probably, had the works been attacked, have proved as inconvenient as such lines did at the investments of Metz and Paris.

The Russians, like the Turks, appear to have been generally content with repairing and prolonging the existing lines. They however carried a fresh line on light poles across the floating bridge at Nicopolis. At Plevna, when the investment was entered on systematically, the six sections, into which after the approved fashion the works were divided, were all duly connected by telegraph. The only striking case, however, of the laying of a field telegraph occurred in connection with Lazereff's remarkable turning movement in the final action with Moukhtar Pasha. Lazereff's force, which for three days was detached from the main body, marched round the Turkish right and struck in rear. With the exception of two accidental breaks of an hour or two, the field telegraph accompanied the advance throughout, a fact that gave that synchronism to the attacks which alone insured success. The distance traversed cannot have been much less than 40 miles.

But few cases occurred of the destruction of telegraph lines. Some Turkish irregulars, who made a raid on Russian territory from Kars, *state* that they broke the telegraph between Alexandropol and Tiflis, at a village called Rokansky, and carried away a mile of wire. In Gourko's first advance across the Balkans, a detachment sent towards Karabunar and elsewhere along the Adrianople-Jamboli railway line, with a view to destroy it, is said, at the same time, to have cut the telegraphs, and similarly, when the Russian army of Rustchuk struck the Rustchuk-Varna railway at Tchervenavoda and Vetova, they of course cut the lines of wires and for the moment isolated the fortress. On the whole, however, if we except the very creditable performance of the Russian Engineers with Lazereff, and without knowing whether the Turkish International line from Constantinople to Keshan was, or was not, tapped on a certain very important occasion, nothing brilliant occurred. Indeed in this respect, as in many others, the absence of Engineers among the Turks, and the general lack of them with the Russian advance, caused the loss of many of those opportunities which were so happily siezed by the Germans and Americans.

Of flag signalling there was absolutely no use with either army. Signal lights were used on both banks of the Danube. The Russians used powerful lights on raised poles. The Turks had a chain of beacon-posts consisting of bundles of tarred straw, on low poles, intended to be lighted, to give notice of an attempt at crossing the river. They were incapable of, and were not intended for, conveying any definite signals.

Refinements, such as electric or lime lights, were hardly to be expected in this war. The Russians, it seems, used one of the former at the commencement of their operations opposite Nicopolis, with the idea of aiding their Artillery fire, but we cannot learn that it proved of any practical value, and we hear no more of it. We understand they thought of using some such light at Plevna; but hearing of the fall of Kars, they were naturally anxious to share the news with the besieged; and went to some trouble to put up "Kars is taken" in Turkish letters of light; this was of course set up in their own lines, which were there 300 to 500 yards, from the Turks; the latter however managed very soon to destroy the illumination with their musketry and shell fire: a very important fact as bearing on the risks that attend the direct use of the electric light for engineering purposes.

### 4. Communications.

Considering the imperfections of the communications, there was, one would have thought, a very wide field for military engineering, particularly in the European theatre of war, in 1877. The only features of great importance, however, under this head, are:—

(1). The passage of the Danube.

(2). The making of a military railway from Bender to Reni and Galatz.

The first is that in which military engineering played its most important part in the war. For, in Asia, though the communciations were execrable, the difficulties were nowhere localized to the same extent.

Denied the use of the sea, the passage of the Danube was the first condition of the problem the Russian staff had to solve. This river, extending 500 miles from Widdin to Galatz, on the whole, favours the offensive from the south rather than from the north, because, in general, the southern bank dominates the northern, and also because the marshes on the latter bank, low-lying, liable to unindation, and cut up by minor channels, render the passage impracticable, except at a few points, owing to the difficulty of constructing approaches to the water through them. The river is liable to great variations of level (as great occasionally as 24 feet). In winter it is sometimes frozen over, and at other times is filled with ice floes of 300 to 400 yards in diameter, which sweep away any floating structures. The current at times reaches four, and even in summer is two to three miles an hour, and the water in mid-channel is in places 30 to 50 feet deep, thus requiring great lengths of cable for pontoons. The bottom however is favourable for holding. The size of the river gives room for rough water, and very light open pontoons are therefore unfit. *

Such is the river over which the Russians had to carry their communications, both in summer and winter.

Immediately after the declaration of war, as we have seen, they secured the mouths of the Sereth and Pruth, by the use of torpedoes and batteries; by the middle of June they had established themselves in force all along the northern bank, and had neutralized the action of the 28 Turkish gunboats on the river. Still the river remained unusually late in flood, and the strong points at Silistria, Rustchuk, Nicopolis and Widdin, narrowed extremely the choice of where to cross; moreover the presence of a numerically strong force in the Quadrilateral, made it necessary to cross West of Rustchuk, or East of Silistria. The latter alternative would have placed the invader between Varna, with its sea base, and the Quadrilateral army, which might even have resisted its advance along the narrow line Kustendji-Tchernavoda. On the other hand the distance to the objective increased directly, the further the crossing place lay to the West, while the assistance to be obtained from the Bucharest-Giurgevo branch of railway diminished.

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* Speaking generally the Danube is highest from March to July, and lowest from August to October. It is also generally low about the end of February. Since 1870 the highest level of the surface at Rustchuk was 70.25 feet above the Black Sea. The lowest level of the surface since 1870 was 45·8 feet, a difference of nearly 24 feet.

The following levels of the river surface at Rustchuk in 1877 were taken by Col. W. O. Lennox, V.C., C.B., R.E., viz:—

| | | | |
|---|---|---|---|
| On 1st April, | 61.83feet | above | Black Sea. |
| ,, 7th May, | 66.0 | ,, | ,, |
| ,, 18th ,, | 66.8 | ,, | ,, |
| ,, 23rd ,, | 67.0 | ,, | ,, |
| ,, 1st June, | 68.3 | ,, | ,, |
| ,, 4th ,, | 68.0 | ,, | ,, |
| ,, 7th ,, | 67.3 | ,, | ,, |

On the 10th of May, the branch line of railway just north of Giurgevo, running to the river was submerged.

The Danube has often been known to freeze and thaw three times in one winter.

Under these circumstances it was decided to create a diversion by throwing Zimmerman across at Braila, and to make two attempts at the same time at Simnitza, and opposite Nicopolis at Turnu-Magurelli.

At the Eastern of the three sites, the neighbourhood of the confluences of the Sereth and Pruth,* rendered the approach of the materials for bridging most easy. At the Western, the Aluta river was, in a measure, favourable, and in it were assembled all the bridging materials, other than those of the four pontoon trains with the army, intended for Nicopolis and Simnitza. At both of these places the Northern bank is commanded from the Southern. At Nicopolis there was an antiquated keep surrounded by nine new field redoubts, and held by a strong Turkish garrison, while at, or near, Simnitza, there was only a brigade with a few guns in position.

The site selected for the bridge at Braila, was below an island about 400 yards "down stream" of that place. Owing to the flooded state of the river, 1,600 feet of trestle causeway had first to be made on the north side, along the permanent way of the railway, which here runs to the ferry pier; the roadway being 5 feet above the rails. Beyond this, the clear water way of about 1,750 feet was bridged by 50 rafts, each consisting of 10 logs about 18 inches at the butts and 70 feet long, all bolted together, and moored with heavy ship's cables of hemp, these rafts supported a roadway about 13 feet wide, provided with rope hand-rails. Beyond this, the debris of the Turkish houses formed a causeway on the south. This work was carried right over the ruins of the village, and extended for several hundred yards inland.

The bridge had been in progress for some eight or ten days, when Zimmerman was ordered to occupy the right bank by the 22nd of June.

On the 21st the centre of the bridge was about to be closed when a sudden flood retarded the work, and on the night of the 21st—22nd, 10 companies of the 69th and 70th regiments, were passed over in boats towed by steam launches. These boats were provided with loopholed bullet proof bulwarks. The passage was successfully performed, and the weak Turkish force was driven back.

* For convenience of communication the invader threw a pontoon bridge across the Sereth.

The completion of the bridge was then proceeded with and, as the waters subsided, it became fit for use.

Besides the four pontoon trains with the army of invasion, * a number of heavy wooden boats, with floors fitted to take six-legged trestles, were made at the mouth of the Sereth, at Galatz, and at Slatina, on the Aluta. These were 34′ 6″ long, 9′ 6″ wide, and 3′ 3″ deep. Those not made on the Aluta were brought by train to Slatina, where all the trestle work was done.

The army pontoons were brought from Bucharest to Baneassa, on the Bucharest-Giurgevo line, thence by road to Beia. The 20 torpedo launches were brought by train, half to Slatina, half to Fratesti, short of Giurgevo; from these places they were taken by road to Flamunda, below Turnu, and to Malu-di-Joss, above Giurgevo, and launched. On the 20th June, those at Malu-di-Joss were used to lay torpedoes at Parapanu, and were then taken by land to Flamunda, where they were again used for a similar purpose on the 24th.

In addition to the distraction caused by Zimmerman, the siege guns at Giurgevo were ordered to open on the 24th against Rustchuk, and fire was opened on the 25th against Nicopolis.

The Russians also fired from Oltenitza across the river to Turtuki, and against Rahova. On the 24th, the Corps Commander of the VIIIth Corps was alone informed of the intention of crossing at Simnitza. The 9th Division was ordered to Piatra, as a blind, and the Emperor appeared at Turnu; only the 14th Division was directed on Beia, for Sistova, with all the army pontoons.

On the Simnitza side there is a long island, low lying and cut up by ditches, it is approached by a fair road, and is usually connected by a causeway and bridge with the Roumanian bank, which, inland of the marshes, is about 30 feet above the river. This island is all bare except at the eastern end, where it is thickly covered with willows 8 to 12 feet high, and in June in full leaf. This was the only concealment the island afforded; the width of the main branch of the river appears to be about 2,600 feet at the place of crossing. The Turkish bank is steep and in places almost precipitous; it rises quickly to a height of from 120 to 150 feet.

Two miles east of Sistova there is a narrow gorge opening on the river from the interior; here the defenders had a post, and had

* Probably four pontoon battalions, each with about 700 feet of bridging material (including 56 half boats), all iron, of the Austrian Birago pattern.

placed six guns in position, with a few others between them and Sistova. The Turks however, in all, cannot have had a brigade in the place. After dark on the night of the 26th, working parties were employed in forming emplacements for a number of field guns along the willow-fringed edge of the island; the pontooners dragged their pontoons over to the same bank, and some country boats, to hold from 15 to 40 men, were also got to the far bank through the willows. The head of the column of attack was next pushed over, under cover, and the men were by degrees got into the boats. At 2 a.m. the boats put off and crossed in 45 minutes. The first boat-loads were fired at by the Turkish sentries; on landing, the men extended as skirmishers, firing where they stood till reinforced. By 7 a.m. General Yolchine's brigade was all over, as well as a battery. The Russian guns on the island could not silence those of the Turks, who fired on the boats and island; but, in part owing to the need for depressing the Turkish guns, only one boat (carrying two guns) was struck and sunk. The Turks after fighting with courage, were presently overpowered. The bridge was then commenced, and by the afternoon of the 27th the Russians had 300 boats at work ferrying over troops. The passage having proved a success, a number of the boats assembled in the Aluta were moved down, under the guns of Nicopolis, in three convoys on the 27th, 28th, and 29th. On the 28th a Turkish Monitor passed the torpedoes at Parapanu, and got almost to the bridge, but left, unaccountably, without attempting anything. The bridge was finished in 4½ days, viz., on the night of the 1st July. On the 29th and 30th June five pontoons broke away; on the 3rd July the bridge nearly broke down under the strain of the trains, and on the 9th a gap occurred in consequence of a storm. There was no bridge head on the Bulgarian side, and the approach to the bridge on that side was the bed of the Tekir brook, which was liable to be flooded from the river.

The Russians passed over—

| | | | |
|---|---|---|---|
| 25,000 | men | on the 26th and 27th | June. |
| 35,000 | ,, | by the 29th | ,, |
| 50,000 | ,, | ,, 3rd | July. |
| 75,000 | ,, | ,, 7th | ,, |

The whole operation, both as regards secrecy and execution must be considered as very creditable to the Russians, and considering the importance of the enterprise, their loss (under 100 men) was extremely small. The great superiority of open pontoons, which can be used as boats, was fully established, but the low freeboard of the iron pontoons, and their liability to sink to the bottom instead of floating as ours do, even when full, was found to be a source of danger. The desirability of providing some sort of "apron" with open boats to keep off the break of waves in large rivers is also a point that suggests itself.

The Russian bombardment of Nicopolis from the North bank was in itself impotent to drive out the defenders; so they had to wait till Krudener marched round from Sistova. He arrived on the 13th, attacked on the 14th, and the place surrendered on the 16th.

After the capture of Nicopolis the Roumanians proceeded to make a bridge. The causeway approaching the left bank passes through more than 2,000 yards of swamp: the river itself runs three miles an hour. The roadway rested on 100 open boats at intervals of 24 feet; these had each a six-legged trestle supporting four baulks, the overlapping ends being clamped with iron screw-clamps to the caps of the trestles. The chesses were secured with ribands and rack lashings, the down stream cables were chains, the up stream hemp, probably because they were longer. All appear to have been undesirably short. The Roumanian bridging material was of the Belgian type.

On the 12th of October the bridge broke down in a storm. On the 5th December, with an east wind, some of the anchors dragged, and on the 6th sixteen boats were swamped and as many more were damaged; for some time the only communication was by means of a bay of two boats, hauled by a steamer from bank to bank. On this bridge, traffic only went one way at a time; this was arranged by a signal flag at each end.

The addition of this second bridge was of extreme importance, as relieving the strain on that at Sistova; and particularly in reference to Plevna.

With a view to the attack of Rustchuk, which was contemplated in July, preparations were made to form a bridge at Pyrgos, just above the fortress, in order to pass the IXth Corps over the river. The Turkish gun-boats at Rustchuk made an effort to interfere, but were driven back by the fire of position guns on the north bank. The IXth Corps, however, could not wait for the work and had to be ferried over and the bridge, which was of boats, was not finished till the end of July.

By way of providing a more secure kind of bridge, the Russians had about 800 tin pontoons, of the Blanchard type, made at Paris and Dortmund. They were 26 feet long, and 4 feet in diameter, carried by pairs on wagons. The superstructure oak; baulks for 20 feet span; the roadway to be double. They did not reach the Danube till after the war, and were not used. After Rustchuk was given up, a raft bridge, 2,700 feet long, and with a cut of six rafts for steamers, was made there of trees.

Looking at the whole series of operations, the chief feature of novelty is the co-operation of portable steam boats and the use of torpedoes as a protection to pontooning.

The great capabilities of the method of *ferrying* for troops alone were brought out in a remarkable way, and also the superiority of the fire of guns on shore over those in gunboats. Although the Russian guns were generally much the lighter, they almost always mastered those of the Turkish floating defences, and while only two ships were destroyed by torpedoes, three were sunk by shell fire on the Danube.

*Railways.*

The only new railway work done in the war was the making, by contract, of the strategical line from Bender to Galatz, a distance of over 120 miles. This was commenced early in the year and was opened in December. The line is a very rough one but, even so, the time taken was extremely short as compared with ordinary railway work. Had the war continued it must have been of great strategical importance, as saving distance and relieving the overcrowded Roumanian single line. In addition to this the Russians connected the disconnected ends of the two lines running into Bucharest by a branch outside the town. They also commenced and worked on a new line to run from Giurgevo to Oltenitza; and on a second to connect Marazesti and Bazeo. Neither of these, however, was completed. The Russians, whose railway gauge differed from the Roumanian, had a number of carriages with telescopic axles; but we do not hear they were very successful. They made great efforts to lay a third rail on the Roumanian line so as to continue a uniform gauge from Russia. The result showed the extreme difficulty and delay there is in doing this on a line already overworked, as was the case in this instance.

The repair of railways in the war appears, in the few cases it was necessary, to have been done, for both sides, by the railway work-people. The only bridge restoration was a temporary timber structure erected alongside a permanent bridge across a branch of the Aluta, which bridge had broken down when the river was in flood.

The Rustchuk army, on its first advance, after occupying Kadikeue sent a mounted detachment to strike the Rustchuk-Varna Railway at Tchervenavoda and Vetova. They cut the telegraph and destroyed about 18 rails with dynamite. The charges had evidently been applied to the webs, as, in some instances, as much as 12 inches of web were blown away with the usual ragged fracture; the delay caused was very slight.

In Gourko's first advance the demolitions were more extensive, owing to his column being accompanied by a strong detachment of mounted Engineers under General Rauch.

With a view to deny to the Turks the use of the two lines of railway between him and Adrianople, Gourko endeavoured to break up both.

On the 23rd July two columns were detached, organised as follows:—

(1). The regiment of Astrakan dragoons and some Cossacks and mounted Engineers directed on Karabunar on the Jamboli-Adrianople line.

(2). The Kazan dragoons and an Engineer detachment to Kayajik, between Adrianople and Philippopolis.

The first column was divided into three parties.

(*a*) A mixed squadron of dragoons and Cossacks and an Engineer party with dynamite went to Kazarli and Belibreg, and damaged the line.

(*b*). A squadron of dragoons with an Engineer dynamite party went from Arabajikeue to Suranu to destroy the railway, and to press on to the Maritza bridge, near the Roumelian Tirnova. They do not appear to have reached the latter.

(*c*). A central column with guns and Engineers, having Karabunar as its objective, destroyed, more or less, 21 miles of line between Kazarli and Karabunar. The Turks, however, held the station at the latter place. This column succeeded in destroying five bridges, three culverts, the telegraph line, a small station, a guard house, and a piece of embankment.

The Kazan dragoons, directed on Kayajik, sent a squadron and Engineers across the Maritza; these destroyed the station, and damaged several miles of line. None of these operations, however, seriously delayed Suleiman's advance; the bridges were all small, and rails are quickly replaced.

In connection with railways we may refer to the use made of road locomotives in this war.

Russia got 12 for the occasion, viz.:—6 from Aveling, 1 from Fowler, 3 from Clayton, and 2 others.

They had complete sets of trucks and 2 portable forges. English mechanics went out to teach their use. The flat country of Roumania was favourable to these engines, and as long as the dry season lasted they got about fairly well on the unmade roads of the country; but it seemed to be taken for granted that they could not work in the wet season. One road locomotive moved a steam launch from Giurgevo to Petrochany along soft roads; another worked the electric light machine used at Turnu-Magurelli; another acted as a railway pumping engine. Several were rafted over to Rustchuk and used there. On the whole these engines drew between April, 1877, and November, 1878, about 9,000 tons, chiefly siege material, for various short distances. The failure to get more out of them seems to have been due to their having been "nobody's children." Aveling's are said to have proved most solid and serviceable; Clayton's were next best. Since the war they have been placed for use in the fortresses.

Although in the campaign of 1877 roads were conspicuous by their absence, still the phases of the campaign shifted so rapidly, and the want of road material was so universal, that time and means were alike wanting for any great road making operations.

From the 10th to the 13th July General Rauch, with his mounted sappers, did good service under Gourko in preparing the Hainbogaz pass, which he rendered passable for wheels; and in the later advance, after the fall of Plevna, the Engineers of the Guard and others gave great help in preparing tracks through some of the minor passes over the Balkans. Road making formed an important part of the business of investment at Plevna, while the Russian army on the Lom was very dilatory in this respect.

The Turks in the wooded parts showed great activity in track cutting for tactical purposes, and the presence of some cutting tools with every battalion enabled them to do this the more readily.

Turkish staff officers told the writer that in the Shipka pass the labour of as many as 12,000 men was employed to form the road by which they brought up some heavy guns for the attack. The Lom army also made a great number of wood roads in their advance by simply cutting down and grubbing up the "stubs."

From Batoum to Souruhissir the Turks made a road for guns along the coast and through the woods, and as it was also used to arm the most Easterly coast battery with 15 centimetre Krupp guns, the bridges, of which there are several, were made of very heavy material, the uprights being piles of 12-inch round timbers, far stronger than was necessary.

Along the Souruhissir position itself, in rear of which were dense woods, a great number of "column ways" were cut in all directions. In these cases the roads were simply formed; nothing was done to make them fit to bear heavy traffic.

Heinman's sappers, in the advance on Zevin, made seven or eight miles of road practicable for guns in four or five hours, and later on the Russians before Erzeroum, in order to stop the Turkish supplies, sent a brigade to Madirga, five miles North-East of the town, and made a road *viâ* Partak to Kiossa-Mahomed. This the Turks partly destroyed.

### *Dams.*

Although, owing to the high level of the Danube, there were many opportunities of flooding its neighbourhood, only one instance of the use of this method seems to have occurred—namely, when Zimmerman drove back the Turkish troops near Matchin at the time of his crossing. These cut the dams and flooded all the country near his bridge-head, so that his troops had to advance "knee deep" in water. The low-lying ground formerly covered by the Danube water between Tchernavoda and Kustendji was peculiarly favourable for the employment of inundations, but apparently the opportunity was lost. At Plevna the Russians dammed the Vid below the town near Surzulu, in order to make the river a greater obstacle to egress. The Turks, however, formed several bridges at the mouth of the great valley which debouches on the Vid, so the inundation was of small account.

## 5. Hutting, &c.

The Russians almost always carried a kind of large shelter tent in pieces divided among and intended to hold six men. The Turks, as a rule, had nothing. The Russians had recourse to hutting only when extreme cold made tents insupportable; consequently, all the huts they made were of the sunken type. In their winter attack on

Erzeroum they provided themselves with such huts in the snows of Deve-Boyun. Round Plevna they and the Roumanians had sunken huts with earth roofs; indeed, this type is almost universal in all these countries, partly, no doubt, because the soil is a clay that keeps out water, and so these habitations are not liable to be flooded, as they would be in many countries. The regular form of Turkish field barrack which was used in winter in all the fortresses is shown in *Fig.* 3, *Plate* I. Besides this, the Turks being seldom allowed to live in the villages, invariably housed themselves with the means at hand. The most common form used is a sort of gipsy hut to hold a few men. The Egyptian contingent generally locked branches together to form booths; but, in fact, each regiment, according to the place it came from, had its own way of housing itself.

This power of dispensing with tents is quite contrary to the old Turkish traditions of past centuries, and, but for it, considering the state of their transport arrangements, all movement would have been well nigh impossible when the weather became too cold to bivouac.

Turkish generals say that on service and elsewhere they found the troops were more healthy in these shelters in the winter than in the villages. Throughout the late war the Turks almost invariably kept the troops out of the villages however convenient these latter might be.

The Russians always used them, and suffered more from typhoid and such like complaints.

One very good arrangement the Turks had is a wattled enclosure for fodder (*Fig.* 5, *Plate* I.), which prevents waste and mess in horse lines.

## 6. Fortresses.

Much attention has been drawn to the fact that, in the war of 1877, a number of fortresses were captured with more ease than many of the field positions thrown up in much greater haste.

The causes, however, are not far to seek. Up to within a few years the Turkish fortresses; for instance, Varna, Silistria, Rustchuk, Nicopolis, Ardahan and Kars, were, both as to site and construction, quite unfit to meet modern conditions; and the last owed the success of its defence in 1854 to well held field works, manned by an army. When a war with Russia was seen to be inevitable, the state of Turkish finances was quite unfit to meet the expenses of efficient fortification in all cases.

At Silistria several new and efficient advanced works were made, but everywhere else the defences of the fortresses were nothing more than big field works; and, except where the ground was very favourable they were none of them *storm-proof.* At Varna, for instance, the new defences consisted of a chain of small field redoubts well provided with cover inside, and which, owing to the accident of soil, were in many cases storm-proof. They were connected by a trench occupying the plateau to the North of the town, while in rear of them were a few more permanent modern works, none of them however entirely secure against assault. On the Southern heights, the ditches of the forts all had earthern slopes, which were only in a measure impassable owing to the stiffness of the clay soil.

At Rustchuk the ditches of the new works were alike open to assault, while little use was made of the materials around them, which were fitted for obstacles. At Nicopolis nine new redoubts had been added to the old place, but these were mere field works, and the bold attack of Krudener, well supported by his artillery, was successful, because the work on the dominant point, which was the key, was carried by a rush at the gorge.

### 7, Siege Works.

#### *Capture of Ardahan.*

At Ardahan the defences were extremely rude, and further, the attack did not, there is reason to think, confine itself to the sole use of the warlike metals. The outworks there are Fort Ramazan, 500 yards to the North of the town; the Senghier Redoubt, 1,500 yards to the South; and the key of the position, the Emir Oglu Redoubt, which is at a distance of three miles from the place; this last was not supported from the fortress, the attack being allowed, on the 14th and 15th of June, to bridge the Kursu and to construct batteries on the height commanding it. After being bombarded for a night the garrison of the work had to retreat on the 16th. The Russians then advanced their guns against Ramazan, and by the evening of the 16th began to bombard it also. They, at the same time, moved round to the South of the town; in doing so, five battalions from the Senghier Redoubt attacked them but were repulsed. The assailants then established themselves on a height 4,000 yards South of the place; employed the night in entrenching it, and commencing at daybreak of the 17th, bombarded the town for seven hours. On the 18th they assaulted in three columns, and after three hours fighting the garrison ceased to resist.

*Kars.*

The fortress of Kars has been described with fair accuracy in the "*Moskovskiya Vedomosti.*" In the war of 1854, several earthworks were added to the defence; and quite recently the Turks made a number of new forts after the design of a Prussian ex-officer in their service; the forts last constructed, were in 1877, connected by a continuous trench and parapet (*Fig.* 1, *Pl.* 1) making the total circumference about ten English miles. The history of these defences is as follows: before the war some portions of the interior masonry were completed and the parapets were made up, but owing to the fact that the sites are nearly all rocky, the construction of the ditches was left to "the zeal of the inhabitants, when the time came."

The time came, but the ditches remained only in design, or they were so shallow (six or seven feet deep) that they presented no obstacles to assault.

Shortly after the declaration of war in 1877, the Russians advanced in force with a siege train and large supplies of 9-inch to 12-inch timber for their siege works. Contrary to the experience of 1828 and 1855 the direction of their attack was from the North, not the South.

The garrison at this time was about 12,000 strong, exclusive of artillerymen and cavalry; half the infantry, it is stated, were required night and day to man the line of defence: even though there was a line of obstacles such as military pits in front. The pits, as it happened, were not unfavourable to the assailants, owing to their being 4 feet 6 inches in depth. The armament is said to have consisted of over 300 rifled guns: there were a very few long 15 centimetre guns on slides with hydraulic buffers*, and some short guns of the same calibre on high siege travelling carriages of German pattern: most of the others were bronze B.L.R. guns of Turkish make.

The Russians, in the first instance, threw up two 2-gun batteries (said to be for 15 centimetre pieces) at no less distance than 6,000 yards. They then proceeded, partly under the shelter of a ravine, to make six batteries at about 4,000 yards from the Turkish works, each being for five 15-centimetre guns. Forty field guns were

* The writer saw some of these at Trebizond before the war.

also employed in the trenches between the siege batteries. The section of the batteries was somewhat as in *Fig*. 2, *Pl*. I. The rifle pits in front were constantly manned. Things having gone so far, the assailants do not appear to have made any further progress. The Russian guns (chiefly light 34 cwt. 15 centimetre guns) are said to have thrown, during all the days of the bombardment, over 32,000 shells (average 2,000 a day), causing altogether 240 casualties, dismounting three guns and three gun carriages, and blowing up, it is said, eight small Turkish magazines. The Turks fired over 17,000 shells, and claim to have blown up 14 Russian expense magazines. Although the shells made a great show of effect on the ground, the Turkish works were, in reality, but very little damaged; and on the 8-9th of July, owing to Moukhtar's advance, the Russians burnt the large supplies of timber they had brought up, and retired unknown to the Turks.

After Moukhtar's final defeat, Kars became garrisoned, much as Strasburg after Wörth, with the wreck of a beaten army. The Grand Duke Michael, having ordered up the siege train, moved round on the 10th November from Karajal to Vairan Kale, on the south, whence Mouravieff had attacked in 1855. During this flank march a sortie was made from Kars, which at first produced some effect on the Russians. The latter, however, repulsed the Turks and, what is remarkable, followed along with them into Hafiz Pasha Fort. The Turks expelled them, but before retiring the assailants removed the breech-pieces of the Krupp guns that formed its armament.

By the 12th of November the Russians had completed some siege batteries on an arc of a circle from Komadsor, on the right bank of the Kars Tchai, through Karadjuren and Azathkeue to the base of the heights West of Vezinkeue. These batteries, with about 50 siege guns, fired against the southern forts, viz., Suwarri, Kanli, Faizi Bey, and Hafiz Pasha: the last was silenced on the 16th, and on the 17th the Russians had information that led them to decide on a night assault: the garrison being at the time less than one man to every three yards of perimeter. The forces to be employed in the operation numbered between 26,000 and 27,000 men, and 144 field guns.

Lazereff, perhaps the most brilliant leader in the war, directed the right column, which consisted of the 40th Division from Vezinkeue. He was to threaten the defences on the Karadagh, to seize Hafiz Pasha, and then advancing up the southern slopes of Karadagh, to take the works of Ziaret in rear.

Count Grabbe, with 14 battalions and the Caucasian rifles, formed the centre column, which advanced from Magardjik to Kosmodar on the Kars Tchai, having, for mission, to attack the Kanli and Suwarri works.

The left attack, under General Roup, was to take the left bank of the river, and threaten or take the Tahmasp Fort: while the Ardahan brigade, under Komaroff, was to attack Mukhliss Tabia. With each column was a ladder party; the ladders were not much wanted: where they were wanted they proved too short. The attack was made about 9 p.m., in clear moonlight, with the support of 52 siege guns.

Lazereff entered Hafiz without difficulty, and advancing up the reverse slope of Karadagh, carried Ziaret Tabia, which was the only closed work, by assigning a brigade to the attack. The right attack also took the citadel with ease.

A brigade of the centre took Suwarri with small effort, and a second attacked Kanli, which consists of two redoubts and a réduit, the whole surrounded by a ditch. Count Grabbe was killed; his successor, a Colonel of Engineers, working round the gorge, where was a masonry blockhouse, had the gorge gates blown in with dynamite. The garrison, after making a stand in the réduit, surrendered under the threat of a further use of dynamite. General Roup captured the Tahmasp work after only a slight skirmish.

The assault had thus been completely successful, and was effected with a loss of less than 10 per cent., and, though some of the causes that brought about success were, we would hope, exceptional, still the Russians deserve great credit for the boldness and skill with which the operations were carried out. The obvious lessons are, that field works, even on the scale of forts, can never be considered as secure substitutes for them by simply calling them so; and that under the new conditions, the enormous saving of loss by assaulting in the dark has largely increased the value of night attacks. It is true that against undemoralized troops the risk is considerable, and that similar attempts failed even before Erzeroum, (*Pl.* II.), but the failure was due to the exceptional energy of the defensive counter attack. At Erzeroum the attack made on the morning of the 9th of November, after daylight, failed altogether; but at midnight a column of 16 battalions advanced against the Medjidieh Lunette and the Azizi Redoubt. The former work was carried by a party with ladders, who assaulted at the salient, and by the remainder of a battalion who entered at the open gorge as dawn broke.

They were at once attacked by Mahomet Pasha, with half a battalion, and driven out; by this time daylight enabled the guns of Azizi to repel the attack completely. Had it been practicable to time the movement, so as to have struck two hours earlier, it might have ended very differently.

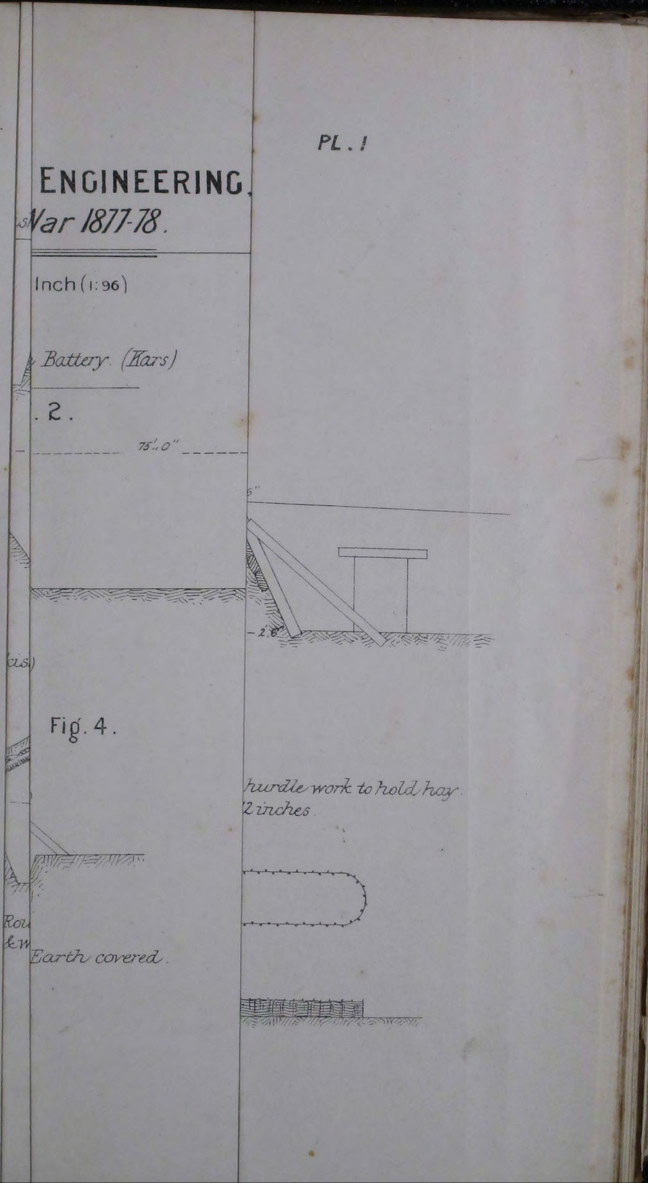
As regards siege questions, the futility of placing siege batteries at great distances, even at the commencement, was, it is thought, clearly shewn by the results at Kars. In other respects the operations of 1877 have added but little to our siege-lore, with one exception, namely: at the bombardment of Rustchuk the Russians brought up an 8-in. R. howitzer, they called it a gun, of about $5\frac{1}{2}$ tons, in five pieces; the heaviest being under 3 tons. The piece had a charge of $\frac{1}{10}$th the weight of the shell. It was mounted at night in battery at Slobosia, in three hours, by an ordinary detachment, and three months afterwards it was readily taken to pieces after firing 130 rounds.

With the ordinary siege howitzer, having a maximum charge of $\frac{1}{15}$th, there can be no difficulty in applying the system, and this will permit of the addition to a siege train of a few large howitzers, the heaviest piece of which will not exceed the weight of the heaviest gun of the unit. Thus, some of over 70 cwt. R. howitzers might be made *jointed* and divisible for transport in weights not much exceeding those of the 40-pr. M.L.R. guns of the light siege unit. Similarly some of the 36 cwt. 6·6-inch R. howitzers might be made as transportable as the 25-pr. M.L.R. gun. Whether in view of the great increase of velocity now obtained in the latest types* of direct shooting guns, the method can be applied to them is, of course, a question for experiment, and one it appears desirable to try.

For instance, the new 6-inch B.L.R. of about 6 tons is plainly in excess of the weight that can, as a rule, be brought up without railways or water. If, in transport, one ton could be separated, it would then be quite manageable, and be a great acquisition to the siege train.

T. F.

* A velocity of 2,740 f.s. has quite recently been obtained experimentally in this country.



PL. 1
ENGINEERING.
War 1877-78.
Inch (1:96)
Battery. (Kars)
. 2.
75'..0"
6"
2.6"
cis)
Fig. 4.
hurdle work to hold hay.
12 inches.
Rou
&W
Earth covered.

# PAPER VII.

# MOMENT OF INERTIA OF PLANE FIGURES OF ANY FORM.

BY LIEUT. G. S. CLARKE, R.E.

THE moments of inertia of figures of simple geometrical form are most readily found by integration. Those of irregular figures, such as a rail section, can be determined by graphic methods alone.

The following simple general method is believed to be entirely new.

Suppose that the moment of inertia of the trapezium *abcd* about any axis XX is required. Draw any ordinates $x_1$, $x_2$, ...... of the trapezium and produce them as shown. Draw any line $rq$ perpendicular to XX. Let $y_1$, $y_2$ ...... be the respective perpendicular distances of $x_1$, $x_2$ ...... from XX, and let $h$ be the perpendicular height of the trapezium. From $r$ set off $r3$ equal to any ordinate $x_3$; join $3q$ cutting $x_3$ produced in $3'$. Repeat the process for all the other ordinates $x_1$, $x_2$, $x_4$, .. (obtaining the points $1'$, $2'$, $4'$...) finally make $rs = ab$.

Let $x_1'$, $x_2'$, ... be the ordinates of $1'$, $2'$, .. measured from $rq$; *i.e.*, $x_1' = 1_1 1'$; $x_2' = 2_1 2'$; etc.

Then—

$$\left.\begin{aligned} \frac{x_1'}{y_1} = \frac{x_1}{h}; \text{ or, } x_1 = h\frac{x_1'}{y_1} \\ \frac{x_2'}{y_2} = \frac{x_2}{h}; \text{ or, } x_2 = h\frac{x_2'}{y_2} \end{aligned}\right\} \text{.........................} (a).$$

and so on.

Now the moment of inertia (I) of the trapezium about XX is $\Sigma\,(x_1' y_1^2) = h\,\Sigma\,(x_1' y_1)$ but $\Sigma\,(x_1 y_1) = \text{Y}.\,\Sigma\,(x_1')$

Where Y is the distance of the centre of gravity of the figure

$rsq$ from XX. Hence calling A the area of the figure $rsq$—

$$I = h.Y.A.$$

To determine I, therefore, it is necessary to know the area of $rsq$, and also the position of its centre of gravity.

So far the construction is of course perfectly well known.

Now, make $rt = h$ and draw $tv$ perpendicular to XX, and cutting the produced ordinates in $1''$, $2''$... ; join any of these points ; *e.g.*, $2''$ to $q$ and draw $2'0$ parallel to $2''q$. Call the distance $2_1 0$, $x_2''$ and set off $x_2''$ horizontally from $2''$, thus obtaining the point $2_1''$. Repeat the construction in the case of $x_1'$, $x_3'$, ... thus obtaining the ordinates $x_1''$, $x_3''$, ... and the points $1_1''$, $3_1''$, ... ; finally draw $sn$ parallel to $tq$ and make $tp = rn$.

Then—

$$\frac{x_1''}{1_1 q} = \frac{x_1'}{1_1 1''}, \text{ or, } x_1'' = \frac{x_1' \cdot y_1}{h}$$

$$\text{Similarly } x_2'' = \frac{x_2' \, y_2}{h} \text{ and so on,}$$

but from $(a)$

$$x_1' = \frac{x_1 y_1}{h} \; ; \; x'_2 = \frac{x_2 y_2}{h} ; \text{ etc.}$$

$$\text{Hence } x_1'' = \frac{1}{h^2} \, x_1 y_1^2$$

$$\Sigma \, (x_1'') = \frac{1}{h^2} \, \Sigma \, (x_1 y_1^2)$$

But $\Sigma \, (x_1'')$ = the area of the figure $tpv$ = A$'$ and $\Sigma \, (x_1 y_1^2) = I$.

$$\text{Hence } I = A'.h^2$$

Since $h$ is known it is merely necessary to obtain the area of the figure $tpv$. This can be done by cutting it up into approximate trapeziums, or very conveniently by a planimeter.

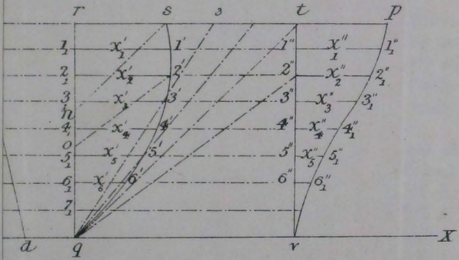
The curve $sg$, which need not, of course, be drawn, is evidently a parabola.

The method is perfectly general and can be applied with equal facility to figures of all forms with any positions of the axis XX, and its great simplicity will be appreciated by any one who tries it.

The construction requires very little more time than the ordinary one, and when completed, it remains merely to find the area of a figure instead of an area and a centre of gravity.

G. S. C.

of Plane Figures of any Form.



# PAPER VIII.

## MEMORANDUM REGARDING DUTIES

PERFORMED BY

# THE R.E. BRIGADE, 1ST DIVISION, PESHAWUR FIELD FORCE,*

*From November, 1878, to March, 1879.*

*Communicated by Brevet Lieut.-Colonel B. Lovett, C.S.I.*

WHILST the brigade was at Peshawur in November, 1878, previous to entering the Khaibar Pass, material was being collected for the R.E. Park. The arsenal at Peshawur not being able to supply all the stores required, some tools were obtained from the Public Works' Department ; the whole amount required, however, could not be completed before the month of February, 1879.

During the advance through the Khaibar the headquarters of Sappers, and Companies No. 2, 3, 6, and 8, with Capt. North and Lieuts. G. W. Bartram, H. Dove, S. H. Exham, E. Glennie, H. S. Leach, J. C. Campbell, R. V. Philpotts and the Hon. M. G. Talbot, R.E., were employed in rendering the road to Ali Musjid passable for guns and in dragging them up. During the night of the 21st November, 1878, before Ali Musjid, two Companies under Captain North, R.E., were posted to guard the left flank of the force and to support General Appleyard's Brigade.

After the fall of Ali Musjid the Sappers were employed in improving, in obligatory places, the road as far as Lundi Kotal, and afterwards they proceeded to Dakka, and were there employed in repairing Dakka Fort. These repairs were carried out under the direction of the fort engineer (Major B. Lovett, R.E.), and the assistant fort engineer (Lieut. Peacocke, R.E.), and consisted of re-roofing sheds, re-building walls, filling up holes in the interior of the place, and constructing outposts for picquets. This latter work was supervised by Captain North, R.E. These works were carried on by Sapper

* Since this Paper has been in type the D.A.G., R.E., has communicated the complete report of the C.R.E., and some further particulars will be given in the next number of *Occasional Papers*.—ED.

labour, largely supplemented by military working parties of the Line and civil labour. On advance of the force to Jalalabad the works at Dakka were handed over to Lieut. Peacocke, and subsequently to Lieut. R. D. Hart, R.E., who is now in charge. The total expenditure on Dakka Fort up to date is about 10,000 rupees, exclusive of military working pay.

Two boats of six and fifteen tons, respectively, were constructed at Dakka Fort for ferrying purposes across the Kabul river at a cost of 160 and 500 rupees, respectively.

On arrival at Jalalabad with Companies 2, 3, and 6, the first works undertaken were road making, and drainage works in camp under Lieut. Talbot, R.E. Lieut. Glennie, R.E., was employed converting a garden near the Kabul gate of Jalalabad city into a defensive post. The work consisted of the almost entire repair of the city wall at that part, and erection of two barracks in the interior, at a total cost of 5,000 rupees.

Major Blair and Captain North, R.E., were employed on the construction of posts for outlying picquets on "Piper's Hill" and on "South Hill," a knoll lying about 1,600 yards south of the camp. These works were completed in February.

About the middle of February the advisability of improving the state of communications with the Peshawur Valley was taken into serious consideration. Major Blair, R.E., was put in charge of works on the roads from Lundi Kotal to Jalalabad ; this work is now nearly completed, having cost about 15,000 rupees.

An alternative road *viâ* Chardeh and Girdi Kas having been determined upon, owing to the reported impassibility of the usual route during the summer months, Lieut. J. C. Campbell, R.E., with the 3rd Company, Bengal Sappers, was despatched on this duty, and commenced work. This work was subsequently taken up by Nos. 2, 3, and 8 Companies and the headquarters of the Sappers under Capt. North, R.E., and the working parties from 17th Regiment, and 45th N.I., together with civil labour, raised the total of workmen to about 800 men daily. Guncotton has been used in blasting on this road to some extent with great advantage. A road 12 ft. broad is now nearly complete.

Outposts at Barikab and at Bosawal, about 200 ft. square, are under construction under Lieut. Peacocke, R.E., and Captain Graves, B.S.C., Field Engineer.

As it was considered advisable to investigate the practicability of an alternative route to Peshawur from Dakka to Michni, a reconnaissance was made in December by Major Blair, R.E,, and information was also supplied by Mr. Scott, of the Survey Department, and Lieut. J. C. Campbell, R.E., and No. 2 Company was despatched to improve the road for a few miles from Dakka, including a steep ascent.

On arrival at Jalalabad it was found that the river Kabul was fordable in only a few places, and it was thought necessary to construct a bridge to last until the melting snow of the hills should swell the river. Accordingly, bridges in three lengths of 170 ft., 170 ft., and 232 ft. were constructed by Lieut. Bartram, R.E.; the trusses used were made up at the Attock workshops on the model of the trusses used for the Attock bridge of boats modified for transport. The roadway of this bridge is 8 ft. wide, and the details of the bridge are as shown in the plates annexed to the detailed report by Lieut. Bartram, R.E. Besides being eminently useful for transport of supplies it was used to pass across detachments of the force on several expeditions.

Early in February orders were received to provide shelter for the Commissariat stores. Two sheds 140 ft. long, being of the section shown in drawings, were erected from designs by Major Lovett, R.E. Each shed can store 3,200 tons of flour.

Orders were received late in February to enclose these sheds by a fortified post.* Work has been commenced. Barracks, for 75 men each, are in course of construction at the salients. Sketches showing details are attached.

The field telegraph train, under organization at the opening of the campaign, was ordered to be left at Peshawur as not likely to be required, but after the advance to Jalalabad, the Government Departmental line having been pushed on towards that place it was thought advisable to bring up the train. This was done, and a wire was lined back to meet the Departmental line. The line worked well for about two months, and was closed on the completion of the Departmental line. The experience has been of good service to the train.

*March*, 1879.

BERESFORD LOVETT,
MAJOR AND BRIGADE MAJOR. R.E.,
1*st Div., P. F. Force.*

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* The trace of this work, called Fort Sale in memory of the defence of Jalalabad in 1841, has been considerably altered in execution. It was completed in June 1879, under the actual supervision of Lieuts. Glennie and Scott Moncrieff, R.E.

## Report on Construction of Bridge over the Kabul River at Jalalabad.

The site selected for the bridge is opposite the small village of Besoot on the left bank of the Kabul river, about a mile below the city of Jalalabad, and nearly opposite the Commissariat Depôt, 1st Division, Peshawur Valley Field Force. The river here runs in several streams through a broad bed of boulders and sand; at the site chosen for the bridge the bed is about 500 yards wide.

At certain seasons of the year (in the summer) the river, swollen with melted snow, is said to fill its bed from bank to bank, and to run with great velocity. In the months of January and February, however, there were only three streams separated by tracts of sand and boulders. The right bank is precipitous, about 25 feet high, and cut up by numerous deep nullahs; the left bank is about 6 feet high. (See *Plate* VII).

The right stream (*Fig.* 1, *Plate* I.) is 55 yards broad, 3 feet 4 inches deep in the deepest part, and runs at the rate of $4\frac{1}{2}$ miles an hour.

The centre stream (*Fig.* 2, *Plate* I.) is 50 yards wide, but only 2 feet 4 inches deep, and easily fordable.

The left stream (*Fig.* 3, *Plate* I.) is about 75 yards broad, 6 feet 3 inches deep in the deepest part, and runs at $4\frac{3}{4}$ miles an hour.

These depths are, of course, liable to frequent variation on account of rain, either local or in the neighbouring hills.

Orders were received to construct a bridge of trestles, with the roadway 3 feet above water level, and to last a month or six weeks, after which time it was supposed that the rise of the river from melted snow would necessitate the dismantling of the bridge.

Trestles of two descriptions were used in the formation of the bridge, viz.:—

1. Five-legged wooden trestles.
2. Trestles constructed of iron telegraph standards.

The wooden trestles were constructed as shown in *Plate* IV., *Figs.* 4 and 5, the centre or fifth leg being adjustable after the trestle was placed in position by a contrivance of Lieut. Blunt, R.E., under whose direction the trestles were made. The centre leg moves freely in a vertical direction, and is fixed in position by a wedge.

The iron trestle legs (*Figs.* 6 and 7, *Plate* V.) were formed of hollow galvanized iron tubes used in India for telegraph standards; these are constructed of wrought iron, rivetted, and in lengths of 6 feet 9 inches each, so that two placed together form a single tube 13 feet long.

With these iron legs double transoms were used; these, bolted together on both sides of each leg, rested on an iron collar screwed tightly on to the standard.

Timber cross braces and sills, also bolted together, completed the trestle.

The greater part of the superstructure of the bridge was formed of roadbearers and chesses, made at Attock, and brought in pieces (on camels with great difficulty) to Jalalabad.

The roadbearers (*Figs.* 8-11, *Plate* VI.) are trussed and fished beams, 20 feet long, giving an available span of about 18 feet 6 inches. Claws (iron) on each end helping to keep them in position.

The centre bridge, and some of the shore bays of the other bridges, were formed of fir timbers 13 feet 6 inches × 3 feet, giving spans of about 12 feet.

Planks, 8 feet × 8 inches × 2 inches, served admirably as chesses after those brought from Attock had been exhausted.

Each bay was formed of three trussed beams, or four of the baulks of local timber.

A ramp (*Fig.* 1, *Plate* II.) having been cut down through the steep right bank of the right stream, a 3-inch rope was made fast to bollards on each bank, and the trestles, &c., brought down by coolies complete from the R.E. Park, distant about three-quarters of a mile.

A traveller was fixed to the rope, and a second rope through this made fast to the up-stream legs of the trestles, helped to get the trestles into position, the traveller being worked by parties on each bank, directed from the head of the bridge.

The trestles, wooden ones, were put in position almost entirely by manual labour of 10 boatmen (from Attock) and a few Sappers, the chief difficulty experienced being due to the floatation of the trestles, which were apt to upset in the deeper water.

The trestles in deep water were towed into position by help of traveller and guy ropes; in shallow water they were simply carried along the bridge and handed down to men in the water.

The centre bridge (*Fig.* 2, *Plate* II.) was formed almost entirely of short iron-legged trestles and local timber, no difficulty being experienced in the shallow water.

The left bridge (*Plate* III.) was constructed partly of wooden and partly of iron-legged trestles, the latter being more easily handled in the deep water.

A rope having been made fast across the river, above the site of the bridge, a large block was hooked on to this which answered all the purposes of a traveller. (*Fig.* 13, *Plate* VI.)

A small native boat was attached to the traveller, in such a manner that motion up and down stream was secured from on board the boat and lateral motion from either shore. (*Fig.* 12, *Plate* VI.)

When the water was too deep for men to work in it, the trestles were put in position from the boat, with assistance of ropes from the legs of the trestles to the head of the bridge and shore. The trestle having been laid across the boat with the butts of the legs towards the left bank, the boat was hauled into place, just above and within the site of the trestle, which was then upset and steadied by men sitting on the transom.

Much difficulty was experienced in the deep water in getting the trestles exactly into position, on account of the strength of the current and the buoyancy of the trestles.

After getting a trestle into position the roadbearers were handed over the head of the bridge and fixed on the new trestle from the boat.

The iron trestles of both centre and left bridges were stiffened by attachment to wire ropes stretched tightly from bank to bank.

The roadway of the bridges was formed of long course grass and earth; this was wetted daily to keep tight the superstructure, lashings, &c.

A small ramp, covered by a bridge head, gave exit on to the left bank.

Causeways were constructed over the lower portions of the river bed (which were only slightly above water level), so that a slight rise of the river should not interfere with traffic.

The left bridge failed to carry a 9-pr. ammunition wagon; the gun passed over in safety, but under the wagon one of the tie rods of the roadbearers broke, and one bay was destroyed, the fracture showing a bad weld at A. (*Fig.* 11, *Plate*, VI).

The damaged trestle was temporarily repaired and bay replaced in about $1\frac{1}{2}$ hours, and afterwards the trestle was replaced.

Appended are photographs (see *Plates* VII. and VIII.), showing the three bridges from the right bank of the river, and a record of one day's traffic, which is probably a fair average one.

G. W. BARTRAM, Lieut., R.E.

*Jalalabad*, 13*th March*, 1879.

*Traffic over Bridge on the* 24*th February*, 1879, *in both directions.*

| | |
|---|---|
| Men ... ... ... | 1500 |
| Grass-cutters ... ... | 1000 |
| Grass-cutters' ponies ... | 1000 |
| Cattle ... ... ... | 720 |

| | | | |
|---|---|---|---|
| Sheep ... | ... | ... | 480 |
| Camels | ... | ... | 280 |
| Pack-bullocks | ... | ... | 300 |
| Donkeys | ... | ... | 52 |
| Horses ... | ... | ... | 70 |

This may be taken as an average account.

Remarks on Lt. Bartram's Report and Bridge Operations.

The construction of this bridge reflects credit on the officers connected with it; also, upon the Sappers and Ghoorkhas who helped them. The Sergeant-Major of Sappers was most useful.

A good deal of careful enquiry, necessary as to the character of the river, its liability to sudden rise, &c., was made by Major B. Lovett, R.E., C.S.I., Major of Brigade.

Accurate sections of the river at the site selected, were made from a skin raft, running along a rope previously thrown across the stream, and upon these sections trestles were arranged in the Park by Lieut. Bartram, R.E., and Lieut. Blunt, R.E.

The road bearers were made to order, on the model of the large ones in the boat bridge over the Indus at Attock, and arranged to take to pieces for transport. Their general plan is good, and their strength ample. In this case their construction was greatly hurried, and no time given for the testing, which should generally be given to such things, and they indicate an efficient element in military bridging.

A difficulty arises in laying trestles at such great distances apart, which might be got over by constructing a rough crane of the road bearers.

The iron trestles were telegraph posts (Hamilton pattern), $\frac{1}{8}$-inch iron, and here also may be said to exist an efficient element of bridging.

The difficulty arising from the warping, cracking, and size of timber, has before suggested the utility of hollow iron for such bridges; but no trial had been made, and I am very glad to have had this opportunity of trying it.

It may be remarked here that a pontoon train, or even a section of one, horsed, would have been of the greatest service. Owing, however, to there being no transport maintained for the pontoon train, and to the suddenness of the campaign, and difficulty of obtaining proper transport, this was not feasible.

The promptness and quietness with which the bridge was repaired by Lieuts. Bartram and Blunt, R.E., should be noticed.

The Attock boatmen, of whom 10 were added to the Sappers, should also be mentioned; they are most expert and handy men, never at a loss. They are the descendants of a body of Hindus, long employed on the Indus, who have a tract of land granted to them by the Emperor Akbar the Great,* for their skill in crossing his army. They decline to accept regular service, or some of them would be a good accession to the pontooners.

As great quantities of pine and fir timber are floated down the Kabul river, no difficulty for want of wood exists.

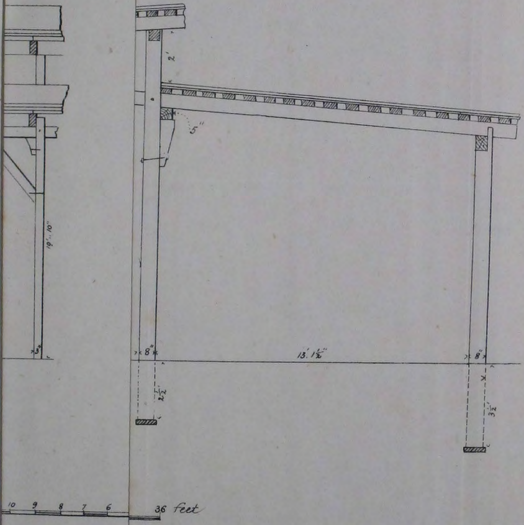
The bridge was commenced on the 20th January, and finished by the end of the month.

F. R. MAUNSELL, Major-General,
C.R.E., *1st Division, Peshawur Valley Field Force.*

*Jalalabad, 14th March,* 1879.

[The bridge was taken down, owing to the advance of the Division, on the 29th of March, under the superintendence of Lieut. Bartram, R.E., in a few hours. The river did not rise more than five or six inches, and finally never rose more than two or three feet up to the 13th June.—B.L.]

* The Emperor Baber (not Akbar), who also descended the Kabul River by rafts.



2'
5"
19'..10"
3"
8"
13'. 1½"
8"
2½'
3½'
10 9 8 7 6
36 Feet

# PAPER IX.

## EXTRACTS FROM THE "REVUE D'ARTILLERIE," 1879.

SUGGESTED BY MAJOR T. FRASER, R.E., AND TRANSLATED BY CAPTAIN H. JEKYLL AND LIEUT. P. L. O. ROPER, R.E.

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### RUSSIAN COMPOSITE 8-IN. SIEGE GUN, CAST (IN STEEL) AT THE FACTORY OF OBOUKHOFF.

THE gun consists of :—

1. An inner tube of steel (3·8-m.) containing rifling and chambers.

An envelope consisting of two parts :—

2. One the breech and trunnions.
3. The other the muzzle part.

The first of these two travels on the siege carriage, and is united to the other by a ring screw collar.

There are two other small pieces.

The weights of the five pieces are as follows :—

| | |
|---|---|
| 1. Inner tube ... ... ... ... ... | 541 |
| 2. Breech ... ... ... ... ... | 2904 |
| 3. Muzzle ... ... ... ... ... | 1826 |
| 4. Screw collar ... ... ... ... ... | 98 |
| 5. Breech piece ... ... ... ... .. | 299 |
| Total .. ... | 5668 kilos. |

The interior tube is carried in a stiff covered box.

The gun was put together and placed at Globosia, opposite Rustchuk, in three hours, after dark, by a detachment of 20 untrained men.

The piece had been previously fired 130 times with 7·8 kilos. of prismatic powder.

Seven shots were fired on the 25th of August, 1877, at 2,900 metres, at an earth battery; one piece said to have been dismounted.*

Six shots were fired at a gunboat on the 1st of September, one of which is said to have hit it.

On the 14th, 16th, and 19th November, 47 shots were fired at 4,900 yards against boats.

The gun stood together for three months, and was then taken to pieces with ease.

The Russians also made a 4-pr. mountain gun in three pieces of 98, 114, and 164 kilos. respectively.

J.H.

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## Experiments made in Russia with Ordnance of Large Calibre—(Composite 8-in. Gun and 9-in. Mortar).

Besides the composite 8-in. and the mountain guns, a mortar of 9 in. on the same principle was constructed and sent to the army of the Danube. Its weight was about 113 cwt., but notes of its details are wanting.

The Russian Artillery Committee is in favour of introducing ordnance into siege parks, capable of being taken to pieces or unscrewed, and approved the 8-in. gun as well as the 9-in. mortar.

With regard to the former it was deemed desirable to modify it by increasing the weight of the central tube and the thickness of the envelopes, and on the other hand to reduce that of the breech and the chase.

It was anticipated that by this means the operation of putting together and taking to pieces would be facilitated, and at the same time by reducing the weight of the chase from 36 cwt. to 26 cwt. the transport of this portion could be effected on the ordinary siege carriage instead of on a carriage specially designed,

Moreover, the height of the carriage used during the experiments—that is to say, the carriage of an ordinary 8-in. mortar, being only 4 ft. 3 in., appeared to be too small when firing at low angles to secure sufficient protection for the piece and its detachment. It would be preferable to substitute a carriage 6 ft. in height.

The Committee believed there would be great advantage in certain

* I think this is a mistake; some of the 8-in. shells lay unburst in the town in September, but I heard nothing of a dismounted gun, and I think I should have had there been one.

cases to have ordnance capable of destroying obstacles of great resisting power, such as thick arches, against which the 8-in. gun would not be effective. The 9-in. mortar might fulfil this condition with its 271 lb. shell, though the results of experiments are not sufficient to establish the fact.

The weight of these projectiles is a considerable inconvenience, and their transport and handling would present great difficulties. Moreover, the breech could not, like that of the 8-in. gun, be transported upon the carriage, as the weight of the whole would reach about 106 cwt. It would be necessary, therefore, to provide a carriage for the breech alone.

Finally, it would be difficult to procure locally the large quantity of massive timber necessary for the platforms to stand the firing of such pieces.

As the solution of most of these difficulties would fall to the lot of the Engineers, the Committee took the advice of General Todleben. The latter strongly favoured the adoption of the composite 9-in. mortar in spite of these indicated drawbacks. He is of opinion that this piece of ordnance will be most useful, not only for the destruction of thick arches, but also for the defence of coasts, where it might not be practicable to bring up other pieces of large calibre to threatened points.

The Committee consequently decided to adopt the composite 9-in. mortar, but before deciding on the actual pattern they asked to be furnished with the details of construction of this description of ordnance, and the results of the experiments which it had undergone before being sent to the active army.

It appeared impossible to construct for pieces of this calibre a carriage which would permit of firing at small elevations, and at the same time fulfil the indispensable conditions for the service of siege batteries.

It would be necessary to rest content with the provisional coast carriage for the 9-in. mortar, upon which carriage the composite mortar had hitherto been placed. If, however, any modifications suggested themselves, they could be laid before the committee.

· Further, it appears that ordnance in pieces would only be employed in exceptional cases, and that it would consequently be useless to introduce them into the two siege parks already existing in Russia. But it would be desirable to collect in a central place, such as Kief, a certain number of these pieces, with all their appurtenances and ammunition, where, in case of necessity, they could be despatched to the southern or western frontier.

The Committee proposes 40 composite 8-in. guns, and 40 composite 9-in. mortars, furnished with 500 rounds apiece. As they might be used against ships, half the projectiles should be of steel, and the rest of ordinary metal.

The form of chamber and that of the shells would be in accordance with the artillery pattern of 1877.

These conclusions of the Committee have been approved.

H.J.

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RESULTS OF EXPERIMENTS AT CRONSTADT WITH A 9-IN. MORTAR AGAINST AN ARMOUR-PLATED PLATFORM, OR HORIZONTAL TARGET.

The shape of the platform was rectangular, 70 ft. in length by 35ft. in breadth, and it was composed of two layers, each consisting of 50 plates, the thickness of the upper layer being 2 inches, and that of the lower 1 inch. The two layers were united by rivets 1·13-in. in diameter.

Under the plating, and in the direction of its breadth, were placed baulks 8·4-in square at a distance of 3 ft. 5 in. from centre to centre, to which the plates were bolted by means of conical headed bolts 1·13-in. in diameter. Under the baulks were three longitudinal beams 8·4-in. square. At the points of intersection of these with the transverse baulks, the bolts served to connect them as well as the plating together. These beams rested upon sleepers of the same section which were supported upon 50 piles 15·7-in. in diameter, driven 5 ft. into the ground. The total height of the mass from the ground to the upper surface of the plates was 5 ft. 11 in.

The 9-inch rifled mortar of steel, loading at the breech, was placed behind a parapet in such a manner that an artificial alignment was needed to lay it by. The weight of the mortar including the breech fastening is 114 cwt. The maximum charge is 18 lbs., giving a range of 5,400 yards at an elevation of 45°.

It was mounted on a provisional iron carriage, on the Semenoff principle. The elevation was effected by means of toothed wheels. The distance of the mortar from the platform was 2,432 yards.

Three kinds of projectiles were fired—ordinary cast iron, hardened cast iron, and hammered steel.

The weight of the first was 271 lbs. The shells of hardened iron were loaded with sand to a weight of 278 lbs., or with powder to 280 lbs. In the latter case the bursting charge did not exceed two lbs., and the weight was made up with lead.

The steel shells were fired either quite empty, and weighing on an average 265½ lbs.; or loaded with from five to six lbs. of powder, to bring them up to a total weight of 271 lbs.

A trial of five shells of ordinary metal proved the laying of the mortar, and determined that for an elevation of 45° the proper charge was 8·36 lbs.

Of the following 36 shells of ordinary metal, none hit the mark. Increasing the charge to 8·59 lbs., out of six shots at an angle of 44° there were two hits, but their effect were very small, and the two projectiles were broken to pieces.

Next were fired 28 shells of hardened metal, at an angle of 51°, with a charge of 9·94 lbs. There were five hits out of these in spite of very unfavourable atmospheric conditions.

The effects were considerable; the two layers of plates were penetrated, even when the projectile encountered a baulk. The bolts were broken and the timber work damaged, but in most instances the shells broke up.

Steel shells empty were then fired with a charge of 9·94 lbs. at an elevation of 57°. Three shells out of eight hit. The effects were much superior to those obtained with the hardened metal shells, although the weight of the latter was greater. The projectiles after penetrating the plates, retained a greater velocity, and remained entire.

Nine shells of hardened metal were then fired with the same charge and at the same elevation as the weighted shells, loaded with 2·25 lbs. of powder. Three struck the platform. The effects were similar to those of the weighted shells, the projectiles broke up before the bursting charge could explode.

Four steel shells out of nine, with bursting charges of from 3·6 lbs. to 5·4 lbs., fired with charges of 9·94 lbs., at an elevation of 57°, struck the target. Only one burst, and scattered its fragments beneath the plating.

Some were of opinion that the bursting charge was insufficient, or that the thickness of metal should be reduced, so as to afford a larger internal space, and at the same time a better chance of inflaming the charge by the shock. Others believed the explosion to be due to the shock and the friction of the grains of powder against the sides of the projectile only, and that if the charge did not burst, it was owing to deficient velocity of the projectile at the moment of impact. The heat developed by the blow, reaches immediately to a very slight depth in the thickness of the projectile, and to make it penetrate as far as the powder it would be necessary to reduce the thickness of metal to a degree incompatible with strength, especially when a cheap description of steel is made use of in the manufacture.

The Committee were of opinion that nothing would ensure bursting but a percussion fuze in the base of the projectile. But this arrangement would only prove advantageous with a large interior charge, and the quality of steel which it is proposed to employ does not admit of greater internal capacity than is possessed by the shells of hardened metal. There is, therefore, no room for researches in this direction.

The Committee concluded that it is simply advisable to abstain from placing the bursting charge in a cartridge in the case of mortar shells, as the velocity on impact of these projectiles is less than that of shells fired point blank against armoured surfaces, and there is no fear of their exploding before penetrating the armour.

Further, the ammunition for mortars for coast service should consist of an equal number of shells of steel, and of hardened metal.

One of the members of the committee, Colonel Spitzberg, entered on the minutes his personal opinion that a percussion fuze would be of great advantage in the case of projectiles containing small bursting charges, whether made of hardened metal or of steel; as the effect of mortar fire against the weakest part of a ship would be considerably augmented thereby.

The experiments of Volkovoïé-polé with 8-inch shells, furnished with percussion fuzes at the base, have already given satisfactory results.

Colonel Spitzberg proposes that the same arrangement should be applied to the shells of the 9-inch mortar whether made of hardened metal or steel.

H.J.

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## Experiments in Firing at Boxes of Remington Small Arm Ammunition (Solid Metal Cases).

The mean result of three experiments showed that the first bullet which strikes a box of cartridges at a distance of 70 yards, blows up the box ; and that about 17 per cent. of the cartridges are destroyed while 83 per cent. may be recovered and used.

The danger of being near a box of cartridges when it blows up is less than might be expected, as the cartridges are thrown a very short distance. However, the experiments have been scarcely so extensive as to be conclusive on this point.

H.J.

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## Explosive Gelatine.

Explosive gelatine is a peculiar description of guncotton, entirely soluble in nitro-glycerine, and forming with it a gelatinous or gummy substance, more powerful than nitro-glycerine, scarcely affected by water and giving out no trace of nitro-glycerine under the strongest pressure.

It can be rendered insensible to mechanical action, while retaining its power, by mixing it with certain substances soluble in nitro-glycerine, such as benzine, &c.

It is composed of 93 parts of nitro-glycerine, and seven of soluble guncotton.

The experiments demonstrated its insensibility to shock, to friction, and to the pressure or action of water, and further, that to produce complete explosion in a free state, and to develop the great force corresponding to its chemical composition, it would be necessary to use, even in its soft state, a peculiarly powerful detonator.

One gramme of fulminate of mercury was insufficient to detonate a charge in a soft state, contained loosely in a tin case. Fragments of gelatine as large as a pin's head, or even of a small pea, were found scattered about after the explosion.

Under the blow of a pile engine, the gelatine was insensible to a blow of 3·5 kilogrammetres, while dynamite instantly explodes under one kilogrammetre.

The gelatine is unaffected by submersion in water, even at a temperature of 158° F., and showed no trace of exudation after eight days, at a temperature of 113° F.

From these properties it would appear very superior to dynamite for military purposes, provided a sufficiently powerful primer can be made to ensure complete detonation.

A new explosive suitable to all requirements has been prepared rom this substance, and may be termed *gelatine explosive de guerre*. It is produced by adding to the gelatine a small proportion of camphor, a substance highly soluble in nitro-glycerine.

A very small proportion of camphor renders the explosive insensible to blows, even of projectiles at short range, it also enables it to resist the action of water, and imports to it an explosive force far superior to dynamite or compressed guncotton.

For complete detonation a special primer is needed of extra power, composed of a mixture of nitro-glycerine with a description of nitro-cellulose prepared in a particular manner.

The composition of *gelatine explosive de guerre* is—

| | |
|---|---|
| Camphor ... ... ... | 4 |
| Explosive gelatine ... ... | 96 |
| | 100 |

Explosive gelatine consisting of—

| | |
|---|---|
| Nitro-glycerine ... .. | 90 |
| Soluble guncotton ... ... | 10 |
| | 100 |

In appearance it is gelatinous, elastic, transparent, and pale yellow in colour.

Its density is 1·6, it can be cut with a knife, and under the severest pressure it shows no trace of nitro-glycerine. At temperature of 122° Fahr. to 140° Fahr. it softens a little, but seldom becomes greasy.

When inflamed in the open air it burns like dynamite or dry compressed guncotton.

200 grammes were placed in a tin cylinder six inches long. When ignited with a slow match penetrating the middle of the charge, it burnt quietly with a long yellow flame, though the case was closed with a metal cover. When half the charge was burnt the cover was simply raised by the pressure without any explosion taking place.

A composition of 10 parts of camphor and 90 of explosive gelatine may be exposed for a week to a temperature of 158° Fahr. without showing any signs of decomposition.

4·4708 grammes of the same composition in a watch glass were exposed for seven hours a day during two months to a temperature of from 104° to 122° Fahr.

No decomposition took place, merely a partial volatization of camphor and nitro-glycerine.

After the experiment the specimen still weighed 4·1239 grammes, so that the loss of weight amounted to only ·3469 grammes, or 7·7 per cent. As nitro-glycerine becomes volatile at 104°, part of the loss is accounted for, so that half the camphor in the composition can scarcely have evaporated, though the circumstances were exceptionally favourable to evaporation.

Experiments are needed to determine the rapidity of evaporation of the camphor, and the effect of its volatilization on the properties of the composition.

The preservative action of camphor, especially at exploding temperatures, is extremely notable.

Thus pure explosive gelatine, slowly heated, detonates at 400° Fahr., or rapidly at 464°.

If 10 per cent of camphor are added it will not detonate at all when slowly heated, but becomes diffused in sparks. When heated rapidly, it explodes at a temperature too high for measurement by ordinary apparatus.

Mixed with 10 per cent., or even 4 per cent. of camphor, this substance will not explode at the same temperature as gunpowder, viz., 570° to 600°, but simply burns, producing sparks.

It may be inferred from the above that its liability to explosion from a blow would be equally slight, especially having regard to the elastic, gelatinous consistency of the material.

It requires a peculiarly powerful fuze to ensure the certainty of detonation. The inertness of the composition increases rapidly with the proportion of camphor. With the addition of only four per cent. detonation cannot be ensured with two grammes of fulminate of mercury, a primer of compressed guncotton, or a mixture of 75 parts of nitro-glycerine with 25 of guncotton, as used in the Austrian service.

A special primer is therefore required. It is composed of 60 per cent of nitro-glycerine, and 40 per cent of a nitrous substance, obtained from cellulose by a peculiar process.

Owing to the composition of cotton, it is impossible to obtain from it tri-nitro-cellulose. In Abel's process much of the cotton is only partially nitrogenized, and some not at all, while Lenk's method is still less efficient.

If sulphuric acid be made to act upon cotton a white powder is obtained, named hydro-cellulose. This substance is extremely susceptible to the action of nitric acid. The result is, as regards explosive force, a highly nitrogenized description of cellulose.

This new guncotton appears in the form of a fine powder resembling flour, but exhibits under the microscope the specific structure of cotton. It is not a great absorbant of nitro-glycerine like Abel's or Lenk's cotton, which are divided by mechanical means, neither does it share their property of becoming gelatinous with this liquid.

The mixture of 60 per cent. of nitro-glycerine with 40 per cent. of nitro-hydro-cellulose yields a soft, white, soapy, and entirely homogeneous substance. 20 grammes can be placed in an Austrian cartridge, which will hold but 15 to 17 of the regulation composition, and thus furnishes a primer capable of exploding *gelatine explosive de guerre*, and surpassing in detonating power all known exploding agents.

H.J.

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## Arrangements for the Defence of the Mouth of the Weser.

The armour-plated works for the defence of the mouth of the Weser will shortly be completed. One battery for nine 21c. guns, and two forts containing 10 turrets, intended for 28c. and 15c. guns have already been constructed in accordance with the approved principles of the present day for coast defences. The armament of the above works will consist of 24 pieces.

The two new forts, situated one on the right and the other on the left bank of the Weser, are built on a sand bank. They are washed by the river at high tide, and are surrounded by inaccessible ground at low tide.

The fort on the left bank is armed with lighter turrets than the one on the right, and has arrangements for these being worked by hand. Ten men can cause a complete rotation of the turret, weighing 492 tons, in five or six minutes. However, by means of a specia contrivance two men will suffice to bring this about. The guns mounted on carriages for *minima* embrasures, are worked by hand power, and can be served quickly enough to fire a round in a minut and a quarter.

There is a steam engine* in the fort on the right bank, which ca

* The *Allqemeine Militär Zeitung* states that this engine is an hydraulic one,

cause the three turrets, weighing 590 tons, to revolve simultaneously and give 17° elevation to the six guns in them.

The chill-cast armour plates which protect the fortifications at the mouth of the Weser have an aggregate weight of 7,529 tons; they were supplied by the Gruson foundry, which has also arranged the sub-structures of the turrets, and provided the ammunition lifts and the carriages for the *minima* embrasure. These armour-plated structures have one great advantage over those hitherto constructed in Europe. Thus, if a piece is struck and rendered unserviceable by an enemy's projectiles in English, Belgian, or other turrets, it has to be left in position till the end of the action, and you are deprived of its fire. In the Weser turrets, on the contrary, a certain apparatus allows the injured piece to be rapidly removed and immediately replaced by another which will continue the fire. Before being consigned to the military authorities the forts will be subjected to experiments intended especially to test the armoured turrets and the guns.

Remarkable practice has already been made with the 28c. guns. Although the maximum charge of 58 kilos. of prismatic powder was employed, the precautions taken at first to fire by electricity and remove the detachments from the turret were soon found to be superfluous. In fact, thanks to the small size of the embrasure, which is just large enough to allow of the passage of the muzzle of the gun, the powder gases cannot enter the turret, and are consequently not offensive to the gun detachments. (*Allgemeine Militär Zeitung* and *Neue Frankfurter Presse*).

P.L.O.R.

# PAPER X.

## ON

# FORTIFIED CAMPS AND FORTRESSES.

BY MAJOR A. PARNELL, ROYAL ENGINEERS.

### I. PRELIMINARY REMARKS.

WHEN, nineteen years ago, a system of fortifying by means of detached forts was proposed in this country for the permanent land defence of places, in preference to the old-fashioned method of continuous lines, an impression appears to have arisen that a new and improved mode of making fortresses had been discovered.

If, however, the idea in question is fully considered, it will hardly be possible to avoid the conclusion that the proposal was virtually to alter the principle of defence to be adopted, and that, in fact, fortified camps were being brought forward as substitutes for fortresses.

Of course, the formation of fortified camps, *i.e.*, of lines of defence formed by detached forts with open intervals between them, was no new idea. And probably, when a place or position has been about to be defended, the question has frequently been asked—is a fortified camp or a fortress the better suited to the circumstances of the case?

It is submitted, however, that there *was* novelty in the notion of attempting to apply permanent fortification to a place solely by means of detached forts, with the view of making a fortress of that place and of employing in its defence a *minimum* number of troops.

It will be admitted that, as a rule, fortified camps involve armies —that they are, in fact, mainly points of *appui* for troops. Hence, on the Continent, and wherever conscription is adopted, and large bodies of trained men are constantly maintained, these permanent camps are capable of affording strategical and tactical advantages, and especially when used—according to the usual Continental practice—as additions or subsidiaries to continuous *enceintes*, *i.e.*, fortresses, as at Paris, Metz, or Antwerp.

On the other hand, fortresses pure and simple, or places fortified solely, or at all events mainly, by permanent continuous lines, seem naturally suited to conditions where the available land forces are in small numbers, where every trained soldier would be much needed in the open field, or where the object to be guarded should be one of particular national value, such as a great naval dockyard and arsenal would be to a maritime nation—in short, continuous lines would seem expressly adapted to countries and places where it might be desirable to employ *garrisons* only in the defence of places, and expedient to utilize, to a *maximum* extent, stone walls in the place of flesh and blood.

Before proceeding further, it will be advisable to submit the following definitions of what are considered to be the properties, conditions, and circumstances of fortified camps and fortresses respectively. (The words not within brackets are common to the definition of both systems, whilst, of the bracketed words, the upper lines relate to the fortified camp, and the lower ones to the fortress.)

(1) {A fortified camp / A fortress} is a place, or position, strengthened by {detached forts or works / continuous permanent fortification} built along certain lines taken up for defence.

(2) The design is based on {tactical / engineering*} considerations.

(3) The defence afforded is that of {an army resting on strong points. / fortifications animated by a garrison.}

(4) It is intended to {give advantages in fighting a battle. / resist a siege.}

(5) It is thus a prepared {battle field. / siege field.}

(6) The works are built {for the assistance of——— / in order to be able to dispense with} an army.

(7) The {army / fortification} is the main defence, the {forts / garrison} being subsidiary thereto.

(8) It is in the most advantageous form when {improvised and thrown up / designed and built} in time of {war / peace} by the {general commanding the army. / military engineers of the country.}

(9) The works should, therefore, be usually of a {field / permanent} nature.

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* Or systematic siege.

(10) The { least / most } efficient application of it is to the land defence of a naval arsenal or dockyard, since :—

(*a*) Field troops can in such places usually least be spared to be shut up.

(*b*) The line of land defence needed for a maritime place is necessarily less extended than what would be required for a purely inland position.

(*c*) It is particularly an object to prevent the capture of such places, as well as their bombardment.

## II. On Continuous Lines.

The notion of substituting detached forts for continuous lines, as already alluded to, did not pass at the time unquestioned. At an Occasional Meeting of the Corps at Chatham, on the 9th January, 1863, the late Colonel H. C. Owen, C.B., R.E., being then Commanding Royal Engineer at Devonport, read a paper "*On Fortification versus Forts*," which was afterwards published as Paper XVII. of Vol. XII. of the *Professional Papers*, wherein he strongly deprecated the policy in question.

Colonel Owen took, as a text for his lecture, a short paragraph of Paper XX. of Vol. IX., *Profesional Papers* (1860), entitled, "*Observations relating to the Works in Progress, and Proposed, for the Defence of the Naval Ports, Arsenals, and Dockyards.*" The paragraph was as follows :—" When the extent of the positions necessary to be occupied in order to protect the dockyards against long range bombardment is considered, it is evidently impossible to occupy them by continuous lines, which must be manned throughout their whole extent, and which fall if pierced at any one point."

This paragraph appears to have been the first formal professional intimation made to the Corps of the intention to introduce into England a system of land defence by means of detached forts, *i.e.*, fortified camps. It moreover comprised, apparently, the only reasoning that was made at the time in support of the intended arrangement, and in justification of the change from the opinions, up to that time generally received, as to what constituted fortification, apart from any consideration of it merely as a point of *appui* for an army.

It is submitted that Colonel Owen demonstrated the weakness of the arguments contained in this paragraph, though, in the discussion that ensued, he certainly received but little support from other officers.

His paper elicited from Captain J. J. Wilson, R.E., a counter-paper headed "*On Detached Works versus Continuous Lines applied for the Permanent Defence of an Advanced Position*," which was published as No. XVIII. of the same Vol. XII. Colonel Owen replied in Paper XV. of Vol. XIII.

To the writer, the two papers of Colonel Owen, taken together, appear to form a model of sound reasoning, and to place the matter in a thoroughly right aspect.

Colonel Owen's main contentions were as follows:—

(*a*) A continuous line is as cheap as a detached line.
(*b*) It can be defended by a smaller number of men.
(*c*) Imperfectly trained troops are not suited to form the garrisons of detached forts.
(*d*) The defence of a continuous line is simple and easily understood.
(*e*) Continuous lines are sanctioned by long experience.
(*f*) An enemy can pass between the detached works.
(*g*) The resistance of the two systems to a siege is greatly in favour of the continuous line.

Colonel Owen, who had good opportunities of judging, estimated as follows for the relative costs of two separate miles of fortified ground on a dry site, the one defended by detached forts of the modern kind placed at central intervals of a mile, and the other by continuous lines, viz:—

| | One mile of forts. | One mile of line. |
|---|---|---|
| | £ | £ |
| Ditches ... ... | 9,000 | ... 18,000 |
| Escarps ... ... | 16,000 | ... 32,000 |
| Counterscarps ... | 15,000 | ... 30,000 |
| Caponiers ... | 15,000 | ... 10,000 |
| Haxos ... ... | 6,000 | ... 3,000 |
| Mortar battery ... | 1,000 | ... 1,000 |
| Bombproofs ... | 60,000 | ... 60,000 |
| Tanks, &c. ... | 10,000 | ... 10,000 |
| Land ... ... | 20,000 | ... 20,000 |
| Total ... ... | 152,000 | 184,000 |
| Deduct for savings in cutting and fillings | | 9,000 |
| Total ... ... ... | | £175,000 |

Difference in favour of the fort system, £23,000 per mile, or about 13 *per cent.* Colonel Owen claimed, however, £16,500 per mile as an additional charge against the forts for the cost of an interior *enceinte*, by which he brought the difference between the two systems to about £6,500 per mile, or 4 *per cent.*, which he considered merely nominal. But the necessity for this inner line does not appear to have been conceded—at all events in practice—by the advocates of the forts.

It is quite possible, moreover, that, in some cases where the detached fort system has been applied, a larger saving than even the 15 *per cent.* shewn above has been effected by not constructing continuous lines—for it is evident that a good deal must depend on the size of the forts and on the intervals at which they are spaced—and it is probable that this diminished first cost has been at the root of the entertainment of the fort system.

If the first cost of the two systems could be made equal, it is not easy to see on what grounds a method of fortification indicated by common sense, sanctioned by tradition, and confirmed by experience, should be abandoned.

To those who are interested in the advantages of continuous lines, a study of Colonel Owen's papers is recommended, but, at the risk of traversing the same ground in a less explicit manner, a few remarks will now be made on the subject.

Continuous permanent lines have, perhaps, been held in light estimation owing to a partial forgetfulness of the great inherent advantages possessed by permanent, passive, obstacles. These advantages may be recounted as follows:—

1st. They have no nerves, and are always in their right places.

2nd. They are as effective by night and in thick weather, as in clear day light, and herein they have a distinct advantage over artillery and musketry.

3rd. There are no barriers to the progress of troops that are more simple, direct, and efficient. A whole army, unprovided with appliances, can no more surmount a 30 foot escarp wall than can one man. Cumbrous means are needed to surmount such walls. and still more cumbrous means to destroy them.

4th. By detaining troops longer under fire, they add to the value of that fire.

As regards the particular length or extent of continuous permanent lines, it is difficult to understand how the relative strength of the fortification is affected thereby, or why, *ceteris paribus*, a continuously fortified circuit of 40 miles should not be in every respect as efficient for its object as one of 4 miles. The troops necessary to garrison the longer line form equally a *minimum* number, and are equally efficacious for their work, as in the case of the shorter line.

To judge from the wording of the latter portion of the paragraph quoted from Paper XX. of Vol. IX., allusion seems made therein rather to *field* lines than to permanent ones. The passage is as follows :—" It is evidently impossible to occupy them (*i.e.*, positions of great extent) by continuous lines, which must be manned throughout their whole extent, and which fall if pierced at any one point."

Now, this reasoning would be exactly applicable to an entrenched position formed of long continuous field lines. Such lines certainly would need to be manned throughout, and would probably fall if pierced at any one point.

But the argument seems hardly to hold good when permanent lines are in question. In the first place, it seems incorrect to say that such lines would need manning throughout. If there is one advantage that such lines afford, it is that they enable a continuous line of defending troops to be dispensed with, for they actually substitute themselves for troops, and allow of the latter being effectively concentrated at the flanks, and at the points of assault.

Secondly, as regards falling if pierced at any one point, surely *not* to be pierced at any one point is the very end of all permanent fortifications, at least such is the teaching that has been handed down to us.

Here, in fact, we arrive at the actual weakness of fortified camps, when considered purely as fortifications. As Colonel Owen pointed out, a line of detached forts is already pierced at many points. Not only that, but the piercings in this system actually form the rule, and the fortifications, or obstacles, the exception. It presents an almost continuous line of breach, and the attack of a fortified camp must, therefore, resemble the struggle for the capture of a breach rather than a methodical siege.

It may also be noticed, with reference to the assumption that great extent of position necessarily involves defence by detached works, that whilst the lengths of the lines of detached forts at Portsmouth and Plymouth (in the latter case from Bovisand to the Tamar) are respectively $16\frac{1}{2}$ and $9\frac{1}{2}$ miles, the *enceintes* of Paris and Antwerp are respectively 15 and 9 miles in length.*

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* At Plymouth the line of defence is divided by broad rivers into four distinct independent positions, viz :—1. From the sea on the right (at Bovisand) to the Plym—length 4 miles. 2. From the Plym to the Tamar, $5\frac{1}{4}$ miles. 3. From the Tamar to the St. German's, $8\frac{3}{4}$ miles. 4. From the St. German's to the sea on the left, $1\frac{1}{2}$ miles. No. 3 position is as yet unfortified. The other positions are defended by detached forts.

## III. On Detached Forts.

Modern detached forts are, it is submitted, made too much in the form of "shell traps." Over a small piece of ground, enclosed on three sides by a high rampart, and in rear either by a masonry keep and gorge, or by a rampart as in front, a great number of men, guns, buildings, and stores are concentrated. The forts are, moreover, naturally situated on conspicuous prominent points, and consequently they are greatly liable to the receipt of a damaging converging fire from a besieger's guns. Under these circumstances, it is hardly to be expected that the forts can make any prolonged artillery defence.

They rely to a great extent on their flanking and cross fire to prevent an enemy from passing between them. But if he essayed to do so before this fire was silenced, as he might if he was in sufficient force, and if he knew that there was nothing in the shape, or of the calibre, of an army to arrest his progress, he would naturally choose a time of thick weather, or dark night, for making his attempt, or, at all events, for making the concentrations of troops necessary for such an attempt; and at these times the artillery fire from the forts would, as an obstacle, be practically useless.

But how far would this fire be an obstacle even in clear daylight? It seems quite a novelty in fortification to rely on fire as an obstacle at all, and the idea does not appear to have been conceived until rifled ordnance was introduced. But if the principle is a true one with rifled guns, it is also true with smooth-bored ones, and engineers would long before have adopted it, and the curtains of bastioned fortresses would have been omitted, both in actual practice and in the teachings of the schools.

Considered as batteries, the forts are clearly not in a strong form, and the ideas of Captain Wagner of the Prussian Engineers, as given in his "*Principles of Fortification*," under the heading of "*Defence of Fortresses*," may aptly be quoted on this point. He says—"As the artillery fight proceeds, the guns mounted in the forts will always have the disadvantage that their position is much more clearly marked than those in the siege batteries, and that, while the fire of the latter is concentrated on all sides of the forts, the guns mounted in them must direct their fire over a larger extent of ground. It will, therefore, be impossible for the forts alone to carry on the artillery fight for any length of time."

He goes on to say that, after the attack has established superiority of fire, "the artillery fight is subsequently carried on by guns in position between the forts. The defenders should throw up batteries similar to the siege batteries in rear of the intervals between the forts. If the enemy's fire appears likely to silence any of these batteries, the guns should be withdrawn, and again brought into action in a new battery thrown up during the night at some other point."

It is submitted that a more feeble arrangement than as quoted above, for the heavy artillery defence of a place claiming to be permanently fortified, can hardly be imagined. The few permanently mounted guns are admittedly in such positions that they must soon give over the contest, and this must then be carried on by siege ordnance from siege batteries hastily thrown up in the open ground between the forts—in fact, the resistance is continued by field operations. And of course, if the defenders have an army fitted to conduct these operations, and proportioned to the amount of unfortified space they have to guard, doubtless they will make a good fight.

It is evident, however, that modern permanent forts are not efficient batteries, and as they manifestly do not form good passive obstacles for a line of defence, it becomes a somewhat difficult task to state with precision what tangible value as a system of fortification they really do possess.

Probably their value as such is entirely of a tactical nature. They may, perhaps, each be considered as battle-field fortresses. Their influence on a *battle* would certainly be great, but their resistance to a *siege*, apart from the assistance derivable from any field force they might have in position between them, would, of necessity, be but slight.*

Turning now to the question of the value of the system of fortified camps generally, it appears that little or no experience can be adduced in regard to such as are formed by rings of permanent forts without *enceintes* or fortresses behind them.

As regards, however, the usefulness of fortified camps when arranged in the manner usual on the Continent—viz., in front of fortresses, it is suggested that Metz and Paris, which furnish our two great modern instances of experience, give somewhat unfavourable witness.

* Of course individual forts would still, in many cases, be of use when placed on commanding points in front of a main *enceinte*, but entirely under fire of, and subsidiary thereto, in fact, when employed according to their original intention—and also, perhaps, occasionally, when placed in elevated situations retired behind a main line, and acting as citadels.

The fortified camp formed by the Metz forts proved to be the ruin both of the disheartened army that sheltered there, and of the fortress in their rear.

The fortified camp at Paris does not appear to have delayed, in any material degree, the starvation-caused surrender that overtook the place. Without any forts in front, the *enceinte* would have held out equally long, if the same tactics had been pursued by the Prussians. And if, in order to shorten the siege of this *enceinte*, they had made a regular attack, their efforts would have cost them, if we may judge by the skilful defensive measures that were adopted by the Parisian Engineers, a fearful loss of life, and an immense expenditure of *matériel*.

It may almost be said that if Metz had been without forts, France might have been saved, and it is clear that places thus defended furnish in a dangerous measure the elements of their own reduction.

It is maintained that the art of fortification has been depreciated by the formation of the great Continental permanent fortified camps, and that fortification, instead of being, as hitherto, the art of enabling the weak to resist the strong, is now, to a great extent, the art of enabling the strong to tie up his troops, and to fight passively instead of actively.

It is, moreover, submitted that engineers themselves are liable to get slightly out of their depth when they undertake to prepare ground in peace time for tactical defence.

A strong case might probably be made out against the use of permanent fortified camps under any circumstances—in fact, for erecting on all occasions where forts were needed, only field forts, and these only after war had broken out, thus making entrenched, in lieu of fortified, camps, and this, whether for aiding the advanced defence of a large fortress, or, as at Torres Vedras and Plevna, for the defence of positions chosen for reasons of generalship during the progress of the war.

Such field forts would probably be quite as effective for their purpose as if they had been built in a permanent manner. They could be thrown up in a comparatively short space of time if the designs for them had to some extent been studied beforehand, and they could be arranged with reference to the views of the General commanding, and to the number of the troops at his disposal.

To all this reasoning it may fairly be replied that Continental nations ought to know their own interests in these matters, and that, so far from any check having been made on the formation of permanent fortified camps by the results of the late Franco-German war, nearly every great Power is now engaged in constructing new strongholds of this nature.

It must, however, be borne in mind that, with these Powers, fortification is not applied according to the original simple intention of the art, *i.e.*, as a means of economizing men. It is used in the hope of obtaining, by means of ready made battle-fields, additional power for their immense armies. And although events have shewn that fortified camps are like double-edged tools, and liable to cut both ways, and to be sources of weakness as well as of strength, still, in the struggle for supremacy, or for existence, which these nations must ceaselessly prepare for, they find themselves obliged to follow each other's example, and unable to dispense with any measures that afford even a chance of advantage over their neighbours, and their trust is that their generals, in the next great war, will have light to use these great camps aright.

Now, one great advantage of an *enceinte*, or fortress, is that it cannot be misused by an incompetent general. It can neither keep troops away from service in the open field, nor can it shelter a dispirited army.

A few words may now be said on the question of bombardment. In a paper by Captain H. Schaw, R.E., in Vol. X. of the *Journal of the Royal United Service Institution* (1866), the following remarks are made with reference to systems of forts surrounding the land fronts of naval arsenals :—" Their primary object is to prevent an enemy from establishing batteries within bombarding distance " of the dockyards " by occupying or commanding the ground suitable to such enterprises by forts so strong and powerfully armed, that, although requiring a small number of men for their garrison, they must be regularly besieged."

It is apparently admitted in the above quotation that the forts are not intended to protect the dockyards from capture, but only to throw difficulties in the way of an enemy attempting to bombard them. But can there be two opinions as to whether it is more important to prevent a naval dockyard from being captured, or to prevent it from being subjected to long range bombardment ?

An enemy's intention in both cases would of course be to ruin the naval establishments. But it is maintained that, if he landed his troops and siege train at all, he would be more likely to endeavour to destroy the dockyard and arsenal thoroughly. And this he certainly could not do without first capturing the place, and afterwards blowing up the docks and buildings, as we did at Sebastopol.

It is possible that a modern naval dockyard, or arsenal, would stand a considerable amount of long range, curved, and vertical fire without being materially the worse for it. The place may, perhaps, appear to the bombarders to be on fire at several points, and to be generally much injured, but they cannot be certain of the actual state of things. They are too far off to see the result of each of their shells, and they know little more than the fact that most of them pitch somewhere near the buildings aimed at. They expend a great quantity of ammunition, and eventually cease their fire, and leave the scene with a reasonable assurance that they have effected damage among the structures and stores of wood, and other inflammable materials that the dockyard may possess, but quite doubtful as to having caused any loss of considerable importance.

## IV. On the Attack of Fortified Camps.

The chances are strong that a modern fortified camp, defended by an *adequate* force, never would be systematically attacked. Taking into account the strength of the position, the army occupying that position, and the guns of the forts, such an attack would require great determination, great expenditure of time and money, and great disregard of losses on the part of an attacker. And it would, doubtless, as a rule, be more profitable for him only to blockade the camp, and to attempt to starve its defenders into submission.

If, however, the position was not properly held; if, for instance, the defenders had no field army, or if they only had a comparatively small moveable force besides the garrisons of their forts, the regular attack or siege of such a camp would probably be easy, and of short duration.

The besieger, having first invested the camp so far as might be necessary, would, at the commencement of his attack, be in this position—viz., he would have in front of him, in the shape of the intervals between the forts, a series of extensive breaches. The main operation of an ordinary siege is, therefore, already done for him. The breaches he thus finds, besides being extensive, permit of easy access to their summits, and are virtually undefended.

Field works could hardly be used by the defenders, unless they had a field army to throw them up and man them, but even if such works formed complete lines across the intervals between the forts, and were thoroughly manned, these openings would still, in a regular siege sense, and so far as regular siege operations were necessary, constitute unfortified spaces, and, practically, breaches in the line of defence.

It may, therefore, be said that all that hinders the attackers from occupying the intervals or breaches in question, is the artillery fire that commands both them and the ground over which he must pass to gain them. His work, then, must consist mainly in silencing this fire, and in making approaches on the intervals.

It will be borne in mind that the kind of attack now being proposed would not apply to the case of a number of detached forts lying in front, and within effective range, of a modern, well-armed *enceinte*, or to the case of a fortified camp enclosing a powerful fortress. In such cases the works of attack would have to be directed against the forts themselves, and two or more of them would probably have to be breached and captured before the fortress itself could be attacked.

Let us now take as a fair example of a fortified camp unconnected with any interior *enceinte* or fortress, and not defended by a field army of adequate strength in addition to the garrisons of its forts, a ring of forts spaced at intervals (central) of 1,800 yards, over a perimeter of 25 miles, each fort being properly garrisoned, and mounting 24 guns, besides any necessary purely defensive armament for the flanking of ditches, &c.

The attacker chooses three forts lying adjacent to each other, which we will call R, C, and L (right, centre, and left), and on the two fronts thus formed he directs his operations.

He makes two attacks, of which the right has its centre directed on a point in the line of defence midway between C and L, and the left on a similar point half way between C and R.

These attacks do not extend outwards beyond the prolongations of the centre lines of R and L. This gives, however, an extent of ground of at least 3,600 yards in length, on which the attacker may dispose the guns necessary to silence the fire of R, C, and L.

The number of guns he needs for this purpose may be taken at double the number that can simultaneously bear on him from the forts in question, and this number may be assumed to be half of the combined armament of the three forts, or 36 guns altogether*; and it may also be assumed that these guns are of the nature, and are mounted in the manner, usually adopted in modern forts.

* 18 in C, 9 in R, and 9 in L.

If he then put 72 guns in battery, of a nature equivalent to those in the forts, and for this he has ample room, and if he direct his fire from a first artillery position, distant some 2,500 to 3,500 yards from the line of defence, he will probably be able to converge a fire on the forts sufficiently powerful to silence their artillery bearing effectively on his two attacks.

Disregarding the long range fire from the forts on the outer flanks of R and L respectively, he would then proceed to push forward, by flying trenchwork, such parallels and approaches in each attack as he might need, and eventually to take up his second artillery position at 1,000 to 1,500 yards distance, from which position he might be expected not only to completely crush the forts' guns, both covered and uncovered, but also to prevent even musketry being employed from the ruined parapets. And, since his siege works would not involve either sapping or mining, he would probably soon establish himself in lodgments on the two intervals between C and L, and C and R, respectively.

The position is thus won, and the fortified camp is at an end. And the attacked forts, if not evacuated, can be breached at the gorge and assaulted at leisure, if such operations are deemed necessary.

The siege, besides being facilitated by there being no breach to make in order to gain the position, and no sapping to be executed, is much assisted and shortened by the fact of the artillery bearing on the attack *terrain* being dangerously concentrated in comparatively small enclosures, instead of being spread out in line, as would be the case in an *enceinte*. Hence (as assumed above) not more than about half of the guns of the three attacked forts can bear at one time on the besieger, whereas, in the case of the line, not only do all bear, but none are, as a rule, in a position to be disabled by enfilade or reverse fire, and a siege train of more than double the strength would, therefore, be necessitated to silence them.

We have been treating of the attack in its purely siege aspect, and under the imaginary notion of the camp not being defended by an army, but it is submitted that it may be taken for granted that, in practice, such a state of things never would happen, and that an army always *would* be present to defend a fortified camp.

In this case, however, the attack would present a very different aspect. So far as the forts were concerned, their fire would, perhaps, be silenced in about the same time, but the besieger is now subject to the following conditions :—

(*a*) He must not only invest the place, but he must also practically contravallate it by field works, as was done at Metz.

(*b*) He must bring up an immense army, complete in all arms, and must make the most powerful dispositions for preventing the loss of his siege troops, and the demolition of his siege works, as the result of constant sorties on a great scale.

(*c*) He must prepare his investing force to receive frequent attacks on their lines from the defending army.

(*d*) His progress towards establishing himself in the openings between the forts will be a nearly continuous bloody struggle with large bodies of the defending infantry, in order to wrest from them, as the siege advances, the outlying posts and positions which they will have occupied on his attack *terrain*, and the various redoubts, batteries, and counter approaches which they will have thrown up.

The siege of Sebastopol is, perhaps, no bad illustration of the sort of prolonged combat that might be expected to ensue, provided the defenders were well victualled and well furnished with *matériel*.

It is submitted that the field operations connected with such warfare as the attack and defence of a well-manned, fortified camp would so overpower in cogency the regular siege operations involved therein, that the difference occasioned by the forts being of a field in lieu of a permanent nature would be but slight, and would probably not be worth the peace expenditure necessitated by building the forts in a permanent manner.

In proportion as the defending field force should be smaller than the number necessary to maintain the line of defence effectively, so would, it is suggested, the duration of the attack, *ceteris paribus*, be shortened. This subject is again alluded to hereafter, with reference to the general question of the numbers of the forces required for the defence and attack of fortified places.

## V. On a Proposed Combination of Continuous Escarps and Detached Batteries.

It is now proposed to submit, in a general way, and without entering into details, the direction in which it is thought that alterations should be made in continuous permanent lines, whenever the cost of giving them their most efficient profile and arrangement would appear to be undesirably great.

A continuous permanent obstacle, either natural or artificial, constitutes the essence of a fortress. If the obstacle be natural, it is usually a precipice or a river, and if artificial, an escarp wall or a wet ditch, but it might occasionally be a line of strong sunken obstructions, or a counterscarp.

Having then provided a continuous permanent obstacle, the next step is to mount efficient artillery behind this obstacle.

Therefore, at the most advantageous sites in rear of it, *detached permanent batteries* might be erected, and guns of powerful calibre be mounted in them, in the manner most beneficial for the development of a heavy fire over the country in front.

We thus obtain a fortress complete in the two principal elements of fortification, and the other usual features of permanent defences, although highly desirable, may yet be considered as of a subsidiary character.

These features are principally as follows :—

1. Ramparts.
2. Ditches.
3. Counterscarps.
4. Glacis.
5. Flanking defences to escarps.
6. Retrenchments, or keeps.

These will now be discussed in connection with the proposed scheme.

1. As regards ramparts, the escarp would be surmounted along its whole length by a musketry parapet, but the real ramparts of the fortress are retired from the escarp, and broken up into detachments in the form of batteries.

2. In the proposed profile, no ditch of the ordinary kind would, in dry sites, be provided, but merely a cutting wide enough to allow an escarp wall to act efficiently, or a sinking capacious enough to conceal an obstacle.

3. The reverse slope of this cutting, or sinking, would vary according to the nature of the ground and of the obstacle, and on steep sites it might disappear, but it would never be revetted.

4. As a rule, there would be no glacis. By this course the extent of land needed to be purchased would probably be lessened.

5. Flanking defence would always be provided for the escarp, but not of a sunken nature, and generally by means of giving the escarp an indented trace.*

6. The batteries would form keeps to the line in front. But permanent retrenchments would also be formed, if money permitted,

* By simply following the contour of the ground a good defensive trace may frequently be obtained. Occasionally the flanks might be casemated and might form defensible guard houses.

at points where the natural assault-resisting circumstances of the ground were unusually disadvantageous.

The above suggestions are more applicable to a dry than a wet site. In the latter, the width of ditch is the obstacle in lieu of the height of escarp.

The proposed batteries would be without ditches or inner enclosures, and might, in many cases, consist simply of lengths of casemated ramparts, built of concrete, and covered in front by thick masks of earth obtained from the excavation for the escarps (or wet ditches) and casemates.*

In Paper VI. of Vol. XIX. of the *Professional Papers* (1871) is a series of proposals on fortification which were made at an Occasional Meeting of the Corps in 1870. The main principle therein advocated was, that direct, or what is now termed frontal, fire is the chief point to be attended to in permanent land defence, and that the *trace* of the works should be simplified and economized to the utmost, in order to allow of the most effective application of this fire.

Acting on these views, (which have not hitherto been adopted in modern forts) the detached batteries would be made as strong as possible, the guns and howitzers used would be such as would have a decided ascendancy over the most powerful that could possibly be put into battery by the attack, the defensive ordnance generally would be mounted and provided for in the most excellent manner known, and the whole of the garrison would be accomodated in shell proof casemates underneath the guns.

The distance between the batteries and the escarps would depend on the following circumstances :—

(*a*). The features of the site, so as to give the best offensive positions to the batteries, and the best defensive line of trace to the escarp.

(*b*). The most advantageous distance from the superior crest for the artillery fire to strike the ground in its front.

(*c*). The distance between the casemates and the musketry parapets and flanks, not being too great to prevent them being quickly manned.

(*d*). The amount of room required for the *minimum* thickness of earthen mask that would be desirable.

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* The batteries, wherever necessary, would have protected communications with the defensive line, and with each other.

It is intended that the whole of the excavation should be absorbed by the masks, musket parapets, communications, &c.

The size of the batteries and their distance apart would depend on the following elements :—

(α). The total number of guns allotted to the circuit of defence.

(β). The length of the circuit.

(γ). The form of the ground, and its command over the country in front.

(δ). The cost of the land.

(ε). The *minimum* number of guns that it may be considered desirable to form into a battery.

(ζ). The *maximum* distance that it may be deemed expedient to place between the batteries.

It is suggested that a strong fortress could be formed by the proposed arrangements. And although the upper portion of the escarp would sometimes be exposed, and there is an absence of sunken flanking defence, and these two circumstances are undesirable both in principle and in practice, still, in order to capture a fortress of this nature, the escarp or obstacle must either be breached or escaladed, or the wet ditch must be passed, and for success in any of these operations it is imperative that the fire of the detached batteries should first be silenced. Now, in the proposed system, the provision of a powerful artillery fire is made a subject of the first consideration, therefore it can hardly be doubted that a good resistance would be made.*

Such a profile and trace would only be *needed* for continuous lines of considerable length, where the expense would be very great if the usual combination of continuous ramparts, revetted and wide ditches, glacis, and sunken caponiers, were adopted.

But, in particular places along the line, this more perfect plan could always be employed, if funds were available. And it need hardly be observed that this ordinary arrangement would always be carried out along the whole length of lines on flat ground of such moderate extent that no engineer would think of supplanting them by detached forts.

As regards the question of cost on a dry site, if Colonel Owen's estimate of £175,000 per mile, already mentioned, be applied to the proposal under consideration, and if one detached battery is allowed in place of each of the forts in the line of forts with which the

* The dispersion of the guns that is rendered possible by this system will tend to reduce the amount of dead ground in front of the lines.

continuous line is compared, and mounting the same number of guns, it is evident that certain deductions may be claimed on that estimate. The deductions may be taken approximately as follows:—

| | |
|---|---|
| 1. Decrease of width of ditches by about two-fifths | £7,000 |
| 2. Absence of counterscarp walls. ... ... | 30,000 |
| 3. Absence of caponiers... ... ... ... | 10,000 |
| 4. Saving on land, say three-twentieths ... ... | 3,000 |
| Total... ... ... | £50,000 |

This makes the cost, per mile of line, of the continuous escarp and detached battery system to be £125,000, which is £27,000 per mile, or $17\frac{3}{4}$ per cent. less than the cost of the detached fort system, as in most cases carried out.

The extra cost of the rear faces, keeps, grand magazines, drawbridges, guardhouses, underground passages, and other works incidental to the nature of modern forts, may be set against the extra cost, in the proposed system, of indenting the escarp or otherwise furnishing it with means for flanking itself, and of the more perfect artillery arrangements.

As this paper is only intended to denote the general outline of the proposed substitute for lines of the ordinary kind, no details or illustrations are now given; but it may be mentioned that these would apparently be very simple, and the system would probably admit of much flexibility both in trace and profile, and of convenient application to any sort of ground or country.

The suggested arrangement is unquestionably an imperfect one, and there is no intention to attempt to induce any other opinion of it. Still, whatever disadvantages it may possess in details, the principle of it is the same as has been, till lately, the principle of fortification from time immemorial.

It is claimed for this arrangement that, gun for gun, man for man, and money for money, it will make a far better resistance than will the detached fort system.

## VI. On the Forces required for the Defence and Attack of Fortified Places.

In Vol. I. of the *Occasional Papers* of the R.E. Institute (1877) is a paper, No. 6, written by Lieut. J. F. Lewis, R.E., "*On the Garrisons required for Modern Fortresses*," in which the author assumes a fortified camp, covering a perimeter of 45,000 yards, or about 25 miles, formed by 9 forts, at intervals of 5,000 yards, and each fort containing, so far as can be judged, about 30 guns. He proposes 28,850 men as an adequate field force for defending this camp, independently of the garrisons of the forts.

This number appears to be based on a calculation that 3 men per yard for a distance of 6,000 yards, *i.e.*, 18,000 men, are a sufficient number to defend two intervals or fronts, and that, as picquets and guards must be provided for these two fronts amounting to 4,500 men, the remainder, or 13,500 men, may be considered as forming a "moveable" field force, competent to aid the picquets of any two fronts that may be threatened around the circuit of defence.

The total number of troops required for picquets and guards is estimated at 14,850. This force, with the 13,500 for the field force, and 500 men added for miscellaneous duties, makes up the number of 28,850 already mentioned.

In the preparation of this estimate it seems not to have been conceded that the attacking army might attempt a surprise, simultaneously, at more than two of the intervals, and that the defenders must be in sufficient force to meet the enemy at all points.

It is submitted that a game of "moveable" defence and attack around a large position is a dangerous one for the defenders, since it involves an inherent advantage for the initiators, *i.e.* the attackers, and that 28,850 men could hardly be expected to defend an extent of open, or field fortified ground, nearly 25 miles in length, against an attack made with all the forces that such a length would permit of. There would appear to be scope for at least 3 men per yard, *i.e.*, for 135,000 men, to assault the intervals between the forts simultaneously.

It may be urged that the fire of the forts would make up for the difference. But the attention of the siege-attached forts would be taken up by the attacker's siege guns. And the oblique fire of common shell or shrapnel, at 2,000 to 3,000 yards range, from the guns of the forts against which no siege operations were directed, could hardly, even by clear daylight, be depended on to make up, in the event of an assault in force on the intervals, for the disparity between the two field forces, whilst by night, or in thick weather, this fire (as before suggested) would, as an obstacle, be probably quite useless.

In fact, the defending field force could scarcely afford to be in much smaller numbers than the attacking field army, at least, if they wished to beat back that army. To defend the intervals between the forts, the defenders have, practically, besides themselves, only the natural strength of their position, and any field works (although the author of the paper under consideration does not give them this latter assistance) that they may have thrown up, to rely on.

It is admitted that the estimate of 28,850 men is not based "on the requirements for making sorties" or "constructing counter-approaches." But, surely, these operations form the essence of a successful resistance of a fortified camp. It will generally be allowed that the defence of such a position would be worth little if not of an offensive nature.

If the numbers of the field troops on each side are nearly on an equality, the influence of the forts and field fortifications on the defenders' side may fairly be reckoned on to turn the scale, and to necessitate a very prolonged siege.

Taking all the circumstances into account, it is submitted that the following would perhaps be a more accurate estimate of the field army needed for such a camp as that in question.

Assuming that 15 guns per fort, or half the armament, can fire simultaneously over the front, and allowing 20 yards of fort, or fortified line, to each of such guns, there are $9 \times 15 \times 20$ or 2,700 yards of ground covered by the forts, and 45,000 less 2,700, or 42,300 yards of ground unfortified, and therefore requiring defence by field troops. Allowing three men per yard for the fighting lines, we get $42{,}300 \times 3 = 126{,}900$ men, and, taking one third of this number as a reserve, we obtain altogether, for the field army, 169,200 men.

Strictly speaking, all this number should be infantry, and the proper complements of cavalry, artillery, and engineers, should be in addition thereto; but it is considered that, taking into account that the right use of the three auxiliary arms will probably much save that of the main one, the number mentioned may fairly be taken as embracing all arms, and hence only the usual proportion of this number would be infantry.

It will be seen that the above estimate is based on the extent of unfortified ground in the line of defence. Therefore, the smaller the combined intervals, the smaller will be the field force required, until, when the whole line is fortified, and there are no intervals, or in other words when the fortified camp becomes a fortress, no field force at all is needed.

But, probably, any estimate for such purposes as calculating exactly the numbers of troops needed for purely tactical purposes, will fall wide of the real requirements of the case. It is evident that such problems are only capable of real solution on the field of battle, and that they cannot be mathematically mapped out beforehand like engineering designs.

Herein appears to be one of the great fallacies of the whole conception of the defence of specific places by means of permanent detached forts. For we see that the forts are first built, and then, later on, the army, to which they are merely aids, has to be estimated for; whereas, if the army were first on the ground, the General Commanding could at once throw up works according to the necessities of that army, and without any chance of making incorrect estimates.

A few words will now be said as regards the garrisons (strictly so-called) of forts and fortresses.

Lieut. Lewis's estimate of the garrison of his 9 forts is 2,700 men. In each fort 15 guns are calculated on as liable to be simultaneously in action, and 20 men are allowed for each of these guns, or 10 men in two reliefs. This gives 300 men per fort, and 10 men per gun, if 30 guns be allowed for each fort.

In Paper VI. of Vol. XIX. *Professional Papers*, already alluded to, 30 men per gun, made up of 10 men in three reliefs, were advocated both for forts and fortresses. And it was afterwards found that this number closely coincided with the actual garrison employed at the largest of the Paris forts during the German siege of 1870.

The adoption of three reliefs, *viz.*: one for duty, one for rest, and one for reserve and readiness, is also based on defensive experience, and probably errs, if at all, on the unsafe side.

Thus, it is maintained that the garrison for the 9 forts should be $9 \times 30 \times 30 = 8100$ men, and that the same garrison would be sufficient for a continuous *enceinte* of the same perimeter as the circuit of forts, and mounting the same number of guns.

It is now, however, suggested that the fort system seems to be somewhat unfavourably dealt with by the assumption of such large intervals as 5,000 yards between the centres of the forts. At the rate of 30 guns per fort, or 270 guns for the whole circuit of defence, there are only about 11 guns allowed to every 1,800 yards. But it is submitted that, in order that a fortified camp may make even a tolerable artillery resistance, guns at the rate of at least 24 per 1,800 yards (as supposed in the attack of a fortified camp already discussed) should be allotted to the line of defence.

This is at the rate of one gun per 75 yards; hence a perimeter of 45,000 yards would be armed with 600 guns in lieu of 270, whether the guns were in forts, or in ordinary fortresses, or in the detached batteries of the particular kind of fortresses advocated in the present paper; and the garrison in each case would be 600 × 30 = 18,000 men. But it would not be necessary that the infantry of the fortress garrisons should be of such good quality as that for the garrisons of the forts.

The extent of unfortified ground in the line of defence now becomes less. Using the same proportion as before, *i.e.*, 10 yards of fortified front per gun, the fortified ground is now increased to 600 × 10 = 6,000 yards, and the open ground reduced to 45,000 less 6,000, or 39,000 yards. Calculating, as before, 4 men per yard (3 fighting, and 1 reserve) we obtain 39,000 × 4 = 156,000 men as the necessary field army.

It will be seen that the main difference between the detached fort system and that now proposed, is in the defence of the intervals, between the forts in the one case, and between the batteries in the other. In the former, the defence is by an army, in the latter, by stone walls.

For a fortified camp of any given extent it is evident that there must be a normal number for the defending field force, which number, taking all things into consideration, is that best adapted to bring into operation the full defensive and offensive value of the position, and to necessitate a siege of a *maximum* duration. Any greater number would be not only useless but weakening, and any lesser would constitute a diminishing of the strength of the camp (independently of the strength of the attacking force) as much as a gap would in a line of continuous escarp.

The duration of the siege of a fortified camp will therefore probably be regulated, *ceteris paribus*, somewhat as follows:—

It will be prolonged according as—

(1). The number of the defending field force approaches the normal number for the position; and

(2). The proportion of the attacking to the defending field force, when the latter is normal, falls short of a certain ratio based on experience and on the qualities of the troops employed on either side, and deemed the most advantageous for the attack.

And it will be shortened according as—

(3). The number of the defending field force falls short of the normal; and

(4). The proportion of the attacking to the defending field force, *when the latter is deficient*, exceeds the ratio above mentioned, up to the limit of the amount needed with this ratio when the defenders are at their normal strength.

Thus, as an illustration of (1) and (3), if 156,000 is the normal number of men (as it is believed to be) for defending a fortified camp of 25 miles in perimeter and containing 25 forts, and if 3 to 2 be the proper ratio (as it is believed to be) for the attacking to the defending field force when the troops on each side are of equal quality, which gives 234,000 as the number of the attacking force, the siege, with these numbers engaged, would be of greater duration than if, at the same position and camp, 28,850 men (the number proposed in paper No. 6, of *Occasional R.E. Papers*), and $\frac{3}{2}$ of 28,850 or 43,280 men, were the respective field forces engaged. And in the latter case, as regards (4), any greater number than 43,280 men, up to 234,000, that the attackers may have, would correspondingly decrease the duration of the siege.

In cases where the defending field forces should be considerably below this normal number, it would appear unnecessary that an attacker should rigorously invest the whole camp. He would probably occupy the principal communications, and would strengthen himself thereat by means of field works armed by field artillery, and he would utilise his cavalry in cutting off supplies and in maintaining a general blockade. But he would doubtless employ his field infantry as much as possible in facilitating and shortening his attack operations.

An endeavour has been made in the appendix to summarize, by means of a table, the circumstances of the various natures of fortified places treated on, and to estimate the numbers of troops involved in the defence and attack of each, and some ratios, not hitherto mentioned, have been adopted for this purpose. All the numbers given in the table are intended merely as approximations, and the object is to afford facility for roughly comparing the merits of the different systems.

## VII. Concluding Remarks.

In a lecture delivered in 1871, by Colonel W. F. D. Jervois, C.B., R.E., at the Royal Institution, on "*The Defensive Policy of Great Britain*," it was proposed to defend London by means of an army resting on a fortified camp.

It was stated that "a ring of about 50 works would at every point afford a strong fortified battlefield, 12 miles from the centre of London." The perimeter would be upwards of 75 miles, or 132,000 yards in extent, and the forts would be from 2,000 to 3,000 yards apart, and they would be garrisoned by 50,000 men. The cost of the works was estimated at £8,000,000. The number of troops needed as a field army to defend the intervals was not given, nor was the number of guns in each fort specified.

Applying to a fortified camp of this extent the estimate (already mentioned) of £152,000 per mile, the cost would amount to £11,400,000. If there were only 50 forts this would be at the rate of £228,000 per fort, which seems a high estimate, but each fort being garrisoned by 1,000 men, would be of large size, and would probably mount between 30 and 40 guns.

Allowing 35 guns to be the armament of each fort, the total armament would be 35 × 50 = 1750 guns, which is at the rate of one to 75 yards of perimeter. And if 10 yards of fortified ground is allowed, as before, for each gun, there will be 17,500 yards of perimeter fortified, and 114,500 yards unfortified.

The garrison of the forts, at 30 men per gun, would be 1750 × 30 = 52,500 men, and the field army, at 4 men per unfortified yard, would amount to 114,500 × 4 = 458,000 men.

The cost of fortifying London on the same circuit by continuous escarps, and detached batteries, would amount at the estimate (already given) of £125,000 per mile, to£9,375,000, whilst, at one gun per 75 yards, and 30 men per gun, the armament and the garrison would be the same as for the fortified camp.

But no field army would be needed, and London would be a strong fortress instead of being a "strong fortified battlefield," its garrison might consist mainly of armed citizens, and our manœuvring armies would be free to act quite independently of it.

Finally, in respect of existing lines of detached forts formed for the land defence of dockyards and naval ports, it is suggested that the following alterations and additions might advantageously be applied:—

(1). With the front and side faces, as strong batteries as possible should be made bearing on an attacker's probable first artillery position.

(2). The forts should be united by permanent continuous escarps; or, in other ways, dependent on the nature of the site, the fortified camps which they constitute should be converted into fortresses.

(3). The portions of the keeps, gorge-works, and rear faces tending to catch the enemy's shells, or to prevent the use of inner lines, should, wherever practicable, be removed.

(4). Offensive guns should be allotted to the line of defence at the rate of not less than one to 75 yards.

*Gibraltar, 31st March,* 1879. A.P.

when applied, respectively,
erimeter.

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|---|---|
| – | Nos. (1) and (3) are as suggested in Section IV. of this Paper. |
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| – | |
| 600 | No. (2) is as advocated in Paper 6, Vol. I. *Occasional Papers*, R. E. Institute. |
| 72 | |
| – | No. (4) is as advocated in present paper. |
| ,000‡ | |
| – | N.B.—On each side the troops are supposed to be divided into three reliefs. |
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| ,000 | |
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ilable.

, and in (5) more than in (4).
ieeded.

ater concealment of escarp.

# PAPER XI.

ON THE

# OPERATIONS OF THE ENGINEERS

OF THE

# FIRST DIVISION PESHAWAR VALLEY FIELD FORCE.

*Communicated by the Deputy Adjutant General, Royal Engineers.*

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EXTRACTS FROM A REPORT BY MAJOR-GENERAL F. R. MAUNSELL, C.B., R.E., LATE C.R.E. 1ST DIVISION, PESHAWAR VALLEY FIELD FORCE, TO THE QUARTERMASTER GENERAL IN INDIA.

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23. Regarding the operations and works carried on by the Engineers. All officers and men of this brigade were fully occupied throughout the campaign, without any cessation not really required for rest. * * * * * *

24. Letter No. 15, of 29th November, 1878, describes the operations on the first advance. Two brigades made a detour, and did not rejoin until after the fall of Ali Masjid. Major Blair and Lieut. Peacocke were attached to them, but no Sappers. About two-fifths of the Sappers, with the first line of equipment, were with the advance of the main column—three-fifths with the rear.

* * * * * * *

25. On the morning of the 22nd November, on the evacuation by the enemy, the Sappers took possession of the fort, drove off a few of the enemy who were still lurking about, and also Afridi depredators who were beginning to plunder. They were subsequently employed in improving the road past the fort.

26. On the 23rd, the Brigade Head Quarters and advanced Sappers moved on to the Lundi Kotal pass or incline, where they

were halted. A road had been cut many years ago by Mackeson, and was in wonderful preservation; it was only near the summit, for about a mile, that any heavy work was required at once. This was attacked at once, but the stream of traffic interfered much with the work, and the men were partly employed in hauling the guns over the obstacles. As soon as this was somewhat reduced, a Company was left on it, and the rest pushed on to Dakka, where extensive works awaited them. Meanwhile the rest of the brigade moved up; a detachment being left for work at Ali Masjid under Lieut. the Hon. M. Talbot, but soon afterwards moved on to Lundi Kotal works. * * * * * *

27. The work at Dakka was building, roofing, and repairing fort, sheds and walls, Major Lovett and Lieut. Peacocke in general charge; collecting timber and material for these, Major Blair in charge; also clearing debris, filling up excavations, drainage, road making in and near the fort. Two boats were also commenced; subsequently used for ferrying at Jalalabad.

28. Some detached works or posts, also picquet posts were constructed by the Sappers under Captain North. As these were very good specimens of small posts suitable to the country, &c., sketches are given, *vide* memo. attached. (See *Plates* II., III., IV. and V.)

* * * * * * *

30. An alternate route to the plains debouching at Michni, the Abkhana route, having been favourably reported upon by the Survey Department and Major Blair, a Company of Sappers, under Lieut. Campbell, was sent to line out and render it passable for camels and mules for fifteen miles, at a ruling gradient of one over five ($\frac{1}{5}$). When this company moved on to Kum Dakka, it was threatened by the Momunds, and another company under Lieut. Leach was accordingly sent to strengthen the detachment, and hasten the opening of the road. The work ordered was completed, but this road was not pushed further.

* * * * * * *

32. After arriving at Jalalabad (see *Plate* I.) on the 20th December, 1878, it appeared likely that the division would remain there for some time, and the following works were executed:— Wood was collected for the different works likely to be required; a large quantity of fir and cypress spars was found cut in the Amir's garden, most of which was brought into park and utilised; purchases were also made from merchants. * * * Several defensible posts were made—one at the Kabul or west gate, suf-

ficient to accommodate a Company, commenced on 30th December, by Lieut. Glennie, R.E.; one at Piper's Hill for a picquet, commenced 1st January, 1879, by Major Blair, R.E.; one on a hill to the south of the camp for a picquet, commenced 10th January, by Captain North, R.E.; also one at Ali Boghan, seven miles off, for a detachment of army signallers, with a guard, commenced on 6th January, by Lieut. Dove, R.E.

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36. Large sheds to shelter commissariat stores* were constructed, commenced 8th January, under Major Lovett, R.E., subsequently continued by Lieut. Glennie, R.E., aided by Lieut. Moncrieff, R.E.

37. An extensive fortified post, designated Fort Sale, was constructed round these sheds, with defensible barracks* at the bastions, calculated to contain 500 men. This work was also under Lieut. Glennie, R.E,, commenced on 20th February.

38. A trestle bridge was constructed over the Kabul river,† protected on the left bank by a small bridge head, commenced on 20th January, completed on 30th, dismantled on 29th March, Lieut. Bartram, R.E., being in charge. * * * * * The truth as to the probable rise of the river could not be satisfactorily ascertained; it did not rise more than two or three feet from December to June.

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40. The construction of the road from the rear was now taken up more systematically; the 2nd Division moving up, took the part to Lundi Kotal, thence onward, was in the 1st Division. Major Blair, R.E., was detailed to the general charge on the 7th January, and remained detached upon it until a short time before the advance from Jalalabad. Heavy work was required at the Lundi Kotal incline; Sappers, pioneer workmen, and extensive gangs of country labourers were employed upon it, until it finally became a fine road.

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43. For various reasons, it was considered advisable to run a new road from Ali Boghan (seven miles from Jalalabad) along the river bank instead of inland; this was reconnoitred and reported on by one of Captain North's officers. A Company sent to commence it on the 17th January, and the Head Quarters, and all available Sappers on the 26th January, not returning until the 20th March; during

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* See *Plate* to Paper VIII., No. 12 *Occasional Papers*, 1880.

† See Paper VIII., and *Plates* I. to VIII. appended, in No. 12 *Occasional Papers*, 1880.

this, extensive work was accomplished, a good road being cut for about eight miles. Guncotton was largely used on the work, giving a useful experience, as well as good results.

* * * * * * *

45 The military field telegraph operations were of great interest and importance, to the public service, as will be allowed when it is known that 5,000 messages were passed over the military line in about nine weeks. A line was put up from Jalalabad to near Dakka, about forty miles, meeting the civil line there, and worked for six weeks. When the civil line moved up, the military was reeled up and waited for the advance, when it was again constructed for about the same distance, thirty-five miles from Jalalabad to Safed Sang, working about a fortnight, the civil line again moving up, and the military reeling up and preparing for a new advance.

* * * * * * *

49. The Head Quarters of the Division and of the Engineers marched from Jalalabad on the 12th April, arriving at Safed Sang on the 15th ; the greater portion of the Sappers being left to complete the fort at Jalalabad. The field telegraph Company marched to Safed Sang, constructing a telegraph line. A light advanced section of the field park also marched; indeed, it was ordered that all equipment should be reduced as much as possible, and arrangements were made for only the first line of Engineer park and Sapper equipment to leave Jalalabad. The company of Madras Sappers had moved on with General Gough's brigade to Futtehabad, towards Safed Sang on the 1st April. Major Blair, R.E., also accompanied this force, and was present at the action of Futtehabad on 2nd April.

* * * * * * *

52. Two posts were constructed between Jalalabad and Safed Sang; one at Rozabad (see *Plate* VI.), by Lieut. Poulter, R.E., and one at Battye, by Lieut. Rawson, R.E., under the general superintendence of Major Blair, R.E.

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54. The stay of the force here was so undetermined, that extensive works for shelter, &c., were not taken up. Some material was collected, and sufficient shelter constructed however. This shelter was simply light spars, with matting covering the tents, leaving a space of a foot between them, and may be considered a good specimen of the sort of work most feasible in the country, and with the means employed.

* * * * * * *

56. The hospital shelter was very convenient, almost too good (see *Plate* VII.) ; it was Lieut. Peacock's design, and ably carried out by him. Sappers and Gurkhas being employed on it.

57. The trestle bridge over the Murki Kheyl river or nullah, was the chief work undertaken. (See *Plate* VIII.) The accounts brought in by our own people were all against the feasibility of a bridge—that the river was sure to rise within a very short time and carry away violently any structure that could be erected, and they pointed to masses of masonry of the former bridge half a mile below it. A careful sifting of the statements made by the country people assured me that the work was feasible and safe; their statements amounted to this, namely:—That no great rise was likely to occur before September or October, and that any very great rise was not at all certain, as it did not occur every year. I therefore, with the General's consent, undertook the work, and carried it through, amidst very general evil forbodings.

* * * * * * *

65. The engineering works on the evacuation were confined to rafting operations from Jalalabad to Dakka. This was the most interesting and remarkable operation we had, and is fully described in the memo. appended.

66. The surveying and sketching required in the field, has been taken up of late years, more by the Quartermaster General's Department, and as parties of trained surveyors from the Government Trigonometrical Survey are generally attached, the duty no longer falls as an ordinary one of Royal Engineers—there is, however, some indefiniteness in the matter. It should be remembered that though all officers may be able to survey, special training is required to turn out useful surveyors.

67. Lieut. Bartram, R.E., has very high attainments in this way; his graphic sketches are very superior, and have been very useful. Copies have been zincographed and submitted to the General Commanding and to others in authority. (See *Plates* IX., X., and XI.)

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(Signed) R. F. Maunsell, *Major-General,*
*late Commanding Engineer,* 1*st Division,*
*Peshawar Valley Field Force.*

*From Major-General F. R. Maunsell, C.R.E., 1st Division Peshawar Valley Field Force, No. 724, dated 10th June, 1879, to the Deputy Adjutant and Quartermaster General, 1st Division Peshawar Valley Field Force.*

As requested in your No. 1373 of the 5th instant, I have the honour to report that, during the embodiment of the 1st Division Peshawar Valley Field Force, the operations of the Engineer Brigade have been of a miscellaneous nature, not generally admitting of much opportunity for special distinction. Both officers and men have done their duty well.

2. The operations have been generally as follows, namely :—

*Road-making.*—In which Major Blair, R.E., also Captain North, R.E., with his Sappers, have performed very efficient work.

*Bridging.*—(1) A trestle bridge over the Kabul river at Jalalabad, constructed by the Sappers under Lieuts. Bartram and Blunt, R.E.; a very good specimen of a military bridge.* (2) A trestle bridge over the Murki-Khel river at Safed Sang, constructed by Lieut. Peacocke, R.E., which bridge deserves special notice as a very good military bridge.

*Construction of Field Forts and Posts.*—In which Lieut. Glennie, R.E., for Fort Sale, at Jalalabad, aided by Lieut. Scott-Moncrieff, R.E.; Captain North, R.E., with his Sappers for Fort Dakka, and the Safed Sang Fort; Major Blair, R.E., for posts at Barakab, Rozabad, and Battye ; also Lieut. Dove, were chiefly employed and did good service.

*Demolitions.*—Chiefly of towers and walls of fortified posts of the enemy. These were effected by parties of Sappers, specially organised by Captain North, R.E., to be ready at any moment, day or night, and were invariably most successful.

*Rafting.*—Of Engineer, Commissariat and other stores, from Jalalabad to Dakka. In this Major Blair, R.E., did most efficient service, and by his energy enabled an incredible quantity of stores to be moved by water, to the great relief of the land transport. Captain Moir, 17th Foot, did very good service in aiding this operation.

*Field Telegraph.*—The field telegraph organised, on a very few days' notice, for this force, and then countermanded (as not being wanted) and left at Peshawar on the march of the Division, was

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* Details of this Bridge have been already given in Paper VIII., No. 12 *Occasional Papers*, 1880.

again taken up when the want was felt. The 6th Company of Sappers, commanded by Lieutenant Stafford, R.E., with Lieutenant Ancrum, R.E., under his orders, had charge of this work:—they put up the line and worked it with great success for six weeks between Basawal and Jalalabad, and also again from Jalalabad to Safed Sang for some time. I consider this work as highly creditable to the two officers mentioned, and to Captain North, R.E., their commanding officer.

My Brigade Major, Major Lovett, R.E., C.S.I., deserves notice for his zeal and energy; his tact and knowledge of Persian were very useful.

Captain Stuart, Bengal Staff Corps, Quartermaster Bengal Sappers and Miners, raised and organised a very efficient body of Pioneer workmen: this body of men did most efficient service, and their efficiency has been owing to the great pains and energy spent on them by Captain Stuart.

3. I would then mention the names of the above noted officers, namely:—Major Blair, R.E., Major Lovet, R.E., C.S.I., Capt. North, R.E., Officiating Commandant of Sappers; Lieutenants Peacocke, Bartram, Blunt, Glennie, Scott-Moncrieff, Stafford, and Ancrum, R.E., also Captain Stuart, Bengal Staff Corps, and Captain Moir, Her Majesty's 17th Foot, Assistant Field Engineer.

I have, &c.,

(Signed) F. R. Maunsell, *Major-General,*
*Commanding Royal Engineer*, 1*st Division,*
*Peshawar Valley Field Force.*

## Report of Operations of the Field Telegraph Train During the Campaign in Afghanistan with the 1st Division, Peshawar Valley Field Force, 1878-79.

1. The trains actually organised for the army taking the field were not on the lines of those originally proposed; for the sanction of Government was only conveyed in letter No. 909, from Secretary to Government to Quartermaster General, of 21st September, 1878, and it would have been impossible to have constructed the carts and obtained the whole of the stores in time. Moreover, orders for a second train were issued immediately after, in letter No. 1240S., of 28th September, from Secretary to Government; and again an

intimation was received of the probability of a third train being required.

2. It was therefore necessary to push on the organisation and the collection of stores with all possible dispatch, and to at once design and submit for orders the lines of such trains as seemed feasible for immediate service.

3. The sanctioned train was two sections, of six miles each, on mules, and two sections, of twelve miles each, on carts; total, thirty-six miles—all insulated cable or ground line. The original proposals included aërial line (termed "semi-permanent" as distinct from the advanced train) about one hundred and fifty miles; and as this had been what was mostly used at the different camps, and as experience was increasing the belief in the need of some aërial line instead of so much ground line, a number of bamboos had been prepared for use, being jointed for facility of transport. A few carts, in supersession of heavy wagons, had also been made up. The train which I considered feasible and serviceable was one section of six miles on mules and one section of twelve miles on carts, or eighteen miles insulated, ground line; also one section of twelve miles on camels—aërial line; grand total, thirty miles.

4. Sanction for this *ad-interim* unit was accordingly applied for and obtained; and the first train in accordance was despached to Mooltan under command of Lieutenant Haslett, R.E., who fortunately was not quite new to the work.

5. Meanwhile the work was at once put in hand, and stores ordered for the original scale—some in the Sapper shops, some in the Roorkee Government Foundry, some in Ferozepore Arsenal, some in the Government Telegraph Department, and some from England. All these were urged to push on work with all despatch possible and forward in batches to Roorkee as ready. British telegraphist signallers were also applied for.

6. Orders to move the Sappers to Rawal Pindi *en route* to Hassan Abdal Camp of Exercise being received, orders were given to the various departments to send the stores to Rawal Pindi. Orders to join the Peshawar Field Force were received after arriving at Rawal Pindi, and orders were then given to send all stores, &c., on to Peshawar; regimental officials having been left at Roorkee, Jhelum, and Pindi to push on the work and hurry on to Peshawar.

7. When orders were received to join the Peshawar Force, various considerations made it advisable to arrange for only pack

transport. The carts could not be ready in time; draught animals were not to be had for them, even had they been ready; and, above all, the nature of the country from all accounts seemed to indicate that pack transport only could be used. Arrangements were accordingly at once made with this view; and with the help of General Maude, C.B., V.C., Commanding at Rawal Pindi, they were very efficiently forwarded by the detaching of a troop of the Rawal Pindi Column mules.

8. By the exertions of those who aided me I was enabled to have a good part of the second train in working order by the middle of November, and ready for the operations of the 1st Division of the Peshawar Valley Field Force.

9. To my great regret at the time, however, as far as utilising what had been so urgently pushed on, it was decided that the train was not to be used then. On the other hand, this released more officers and men who were badly wanted for the heavy roadwork in prospect; half of these supposed efficients, having been their third year at Peshawar, were dreadfully reduced in physical capacity.

10. Any further training was accordingly suspended for the time, and all field telegraph equipment and transport left at Peshawar on the march of the Division.

11. The organisation we, however, pushed on as far as circumstances allowed. The transmission of the stores to complete, and of the signallers for working, was not interfered with; also a detachment of the company which was under training was ordered up from Calcutta torpedo operations. All the stores likely to be useful, including a quantity of poles prepared at Roorkee, were got up also.

12. It was not until the Head Quarters of the Division had moved to Jalalabad that it was deemed advisable to attempt any telegraph operations. The Sappers were incessantly worked on roads, defensible posts, expeditions, Dakka Fort, &c. The stores had not all arrived: the postal arrangements were very efficient, and they were aided, as well as the country and the danger of the service allowed, by heliograph signalling; and the Government civil line was advancing steadily.

13. As these causes were not so operative after arriving at Jalalabad, as the want of telegraph communication was made felt, and as with all exertions the civil line could not open for some time, the train, with all stores arrived at Peshawar, was ordered up, so

that a good length of aërial line might be put up to bridge the space to the Government line.

14. A portion of the train arrived at Jalalabad on the 8th January, and arrangements were at once made to construct the line thence to Dakka, nearly forty miles. There being a delay about transport of the aërial line, the ground line was first laid. The distance was unusually long for such a line; but as there was a superabundance of cable line, and experience was very desirable, it was thought advisable to try it. The result proved the great difficulty of maintaining such a length of ground line. The rest of the stores having come up, the aërial line supplanted the ground line. The ground line worked from 25th January to 10th February; the aërial from 10th February to 10th March, during which time upwards of 3,500 messages were passed along the line.

15. On the 10th March the Government civil field line opened office at Jalalabad, and the military line was reeled up ready for further operations to the front in case they might be required.

16. The Division Head Quarters moved from Jalalabad towards Safed Sang on the 12th April, making three marches to that place about thirty-five miles distant. There being a force in advance of Jalalabad (namely, at Fatehabad, about 18 miles), the aërial field telegraph was constructed to that place on the 10th April, or on the eve of the Head Quarter march, and was thence pushed on with the Head Quarter force; communication being kept up uninterruptedly during the march by aid of the mule ground line, which enabled the interval from the aërial line to Head Quarter camp to be covered while that line was under completion.

17. The Head Quarters arrived at Safed Sang on the 14th April. The field telegraph office was opened the same day, and continued working at Safed Sang for nineteen days, until the civil line, as before, was enabled to bring up their heavier line and offices, when the telegraph line was again reeled up ready for operations to the front. The pressure on the office was so great at Safed Sang at first, that both civil and military offices were kept open for several days. The total number of messages, in nine weeks, was upwards of 5,000.

18. In the organisation of the train, and in the operations which followed, acknowledgement is due to those who mainly contributed to bring it about; they are indicated in paragraphs 19 and 20.

19. The cordial manner in which the Director General of the Government Civil Telegraph Line, Colonel Murray, worked with

me, and the promptness with which he supplied the stores required from his department, was most notable. Mr. M. Luke, the Superintendent on the spot, was also ever ready to aid the military offices and line, and to attend to any suggestion from me. And I may say the same of my own people. All worked as if in one department. Nothing could have been more satisfactory: and this greatly facilitated operations and enabled us to acquire useful experience.

20. The undermentioned officers and soldiers deserve mention:—
Captain North, R.E., Commandant of Sappers, for his general attention to the requirements, and the aid rendered by his officers.

Lieutenant Blunt, R.E., Instructor of Army Signalling and Telegraphy, who had charge of the stores and superintended the general working of the train and offices most carefully and assiduously.

Lieutenant Bartram, R.E., and his Conductor, Mr. Grant, of the Sapper Park, for the vigorous and efficient way they pushed on the construction of apparatus.

Lieutenant and Adjutant Exham, R.E., who was the first officer who took up charge of the field telegraph company and train.

Lieutenant Stafford, R.E., who took up the charge from the Adjutant, and his subaltern.

Lieutenant Ancrum, R.E., upon whom devolved the labour of constructing and repairing and taking up the lines; and this was sometimes very laborious.

The four British soldier signallers were thoroughly conversant with their office duties, and worked very well indeed.

The rest of the telegraph company, British non-commissioned officers and natives, all worked admirably. Although new to the work, they showed great interest, zeal, and pride in their work.

21. I must be allowed to add that, without the aid of General Maude, C.B., V.C., I doubt whether I should have succeeded in obtaining the proper transport animals—mules.

22. The Telegraph Train Company was made available for general service work whenever feasible. As soon as the civil line office opened, as a rule, the Telegraph Company was taken off division duty and rejoined the Sappers.

23. When both civil and military lines were working in conjunction, the junction was not carried through by wire, but two offices (one of each) were kept open in juxtaposition, messages being handed over. The rules and arrangements of the two

systems and the control of the establishments could not be perfectly assimilated under one head; and this seems the only feasible system, and worked perfectly smoothly.

24. *Transport.*—The usual trouble in loading, and with the unmanageable camel-loads, occurred. This cannot be completely overcome yet, but some improvements have been noted as necessary in the arrangement of loads.

25. The mules selected for the purpose were of very good description, but it was some time before they fully agreed to their loads.

26. Very great inconvenience was caused by the muleteers not being trained servants, and it was a long time before the proper muleteers could be arranged for by the Commissariat. The men were not efficient; they got neither pay nor clothing, and were not properly amenable to the officer in command for the duties of the train. The officer in charge envied the facility and promptness with which similar equipments were loaded, and with which the muleteers worked in the Mountain Battery.

27. The numerous changes of the Sappers between one Commissariat officer and gomashta and another resulted in loss of papers, and in the muleteers getting no pay at all and in frequent delay in obtaining rations for men and animals.

28. *Efficiency of military line.*—Stores for the line a good deal in excess of what was actually used were obtained. It was not known how much would be required; it was also desirable to test the various descriptions existing in India.

29. The sanction to use aërial line, in supersession to the cancelment of the proposed plan for a semi-permanent line, indicated, as experience showed, the most feasible system by which a term is interpolated—a length of flying aërial line—between the semi-permanent line laid by the civil department and the military ground line.

30. The proper description of ground line has never been supplied yet. A specimen, six miles in length, was obtained direct from England by the Commandant of Sappers some six years ago, and it was found most complete in every way; but all the other cables supplied have been much too heavy for our purposes. That sent from England by the Secretary of State, in lieu of the description asked for, which was only 180 lbs. a mile, weighed 440 lbs.; and this simply means more than double the transport. A variety of cables were sent up by the Director General at my request, in order

that we might test and decide upon them. They were all more or less efficient in themselves, that is, as to insulation and conductivity; but none answered our requirements as to weight.

31. The ground line, which has been brought within the feasible weight by denuding it of its outer coat, was very convenient as to weight, but not up to the mark in strength. An opportunity was taken to try a great length of ground line, namely, when arrangements for the aërial line were not complete, from near Dakka to Jalalabad, some thirty-five miles. The experience was useful; but it showed forcibly the absolute need of using aërial lines. A long ground line cannot easily be protected.

32. The general efficiency of the detail of the line may be considered to have been very satisfactory.

33. The doubts as to the length of lines that would be required, that could be properly worked, or that should exist as a regular organisation, were pretty well and satisfactorily set at rest. All the experience, working alone or with the civil line, tended to show that, both for economy and efficiency, the ground line might be reduced, and that as much aërial line as could be conveniently and rapidly carried should be added; about fifty miles of this ought to cover all contingencies, as long as the regular civil field line was following up.

34. No difficulty was found in obtaining poles, generally of from fourteen to eighteen feet; but these could not be carried on camels as the jointed bamboo poles were, which were in nine feet lengths, forming eighteen feet poles.

35. The rules for working the offices, which were compiled before the campaign on the basis of the Government civil line rules, were amended from time to time as found necessary.

The facility in sending messages, which indeed was a special aim in the system, seemed rather to tempt an undue use of the line. Numbers of messages, evidently unnecessary, were despatched; but it was not thought wise to touch the question at the time, as far as official messages went. A sufficient check has been entered in Rule 14, which will not inconvenience public service.

36. *Personnel.*—Every one had taken to the work without much previous experience. Fortunately time allowed for their picking up some ideas and practising, and zeal did a good deal. But the want of a knowledge of detail was greatly felt, and many difficulties and delays arose from it.

37 The system for supplying a sufficiency of British soldier signallers failed. The paucity of the number obtained resulted in delays and in overworking of the men. They are no use until they have been grounded in an office with regular hard business going on; and the demand for men for the different columns was made beyond what the supply could stand. I submitted in my letter in October last to the Quartermaster General that the number of men in offices in Bengal should be doubled; and, no doubt, measures to meet this want have been made. It was necessary to make over our signallers, whenever we were not absolutely using them, to the Government civil line.

38. *Visual signalling.*—As the visual signalling arrangements were kept quite distinct and not connected with me, I refrain from making any specific remarks about them. A report has no doubt been made through the Assistant Quartermaster General of the Division, who kept the control of the system immediately superintended by Lieut. W. Smith, R.E. But as I had been Superintendent of Army Signalling of the Bengal Army, and desirous of furthering efficiency in it, I may allow myself to remark that the country and circumstances offered peculiar facilities which were taken advantage of, as well as difficulties which were met satisfactorily.

(Sd.) F. R. MAUNSELL, *Major-Genl.*,
*late Comdg. Royal Engineer, 1st Division,*
*Peshawar Valley Field Force.*

*Roorkee,*
*11th August*, 1879.

(Sd.) SAM. BROWNE, *Lieut.-Genl.*,
*late Comdg. 1st Division,*
*Peshawar Valley Field Force.*

*15th August*, 1879.

### *Rules for Military Field Telegraph Train Offices.*

1. The Rules for Military Field Telegraph Offices are framed in accordance with the Civil State Telegraph system. They are of course subject to modifications by the General Officer Commanding the Force.

2. With the exception noted in Rule 4 (when charges for private messages are especially ordered), there will be no money transactions connected with telegraph business, nor any telegraph stamps kept in the offices: all messages taken at, or issued from, military offices being free, whether they pass over an intervening portion of a Government paying line or not. If addressed to, or

issued from, a Government office requiring payment, they will be "*bearing.*"

3. Foreign messages cannot be sent direct (except by Press correspondents, *vide* paragraph 15); they can of course be arranged for with a private agent in India.

4. Private messages will only be liable to charges if the General Officer Commanding considers it necessary either to meet the charges for an extra establishment entailed by their transmission, or to protect the signallers from overwork, &c. The charges would generally be one-fourth Government civil rates; they would only be required at the office of despatch; no payment for messages delivered from an office would be required; they would still of course be "*bearing*" as to payment of transmission along the civil line.

5. There are four classes of messages in order of precedence, and with code signals to be used by signaller to indicate the class, as follows:—

| | | | |
|---|---|---|---|
| I. | Clear the line | Code signal ... | 0 0 0 |
| II. | Precedence | ,, ... | XS |
| | ,, telegraph service | ,, ... | XT |
| III. | State | ,, ... | S |
| | ,, telegraph service | ,, ... | T |
| IV. | Private | ,, ... | P |
| | ,, (if to any office which is not a field office) | ,, ... | P. bg |
| | ,, foreign | ,, ... | F. P. bg |

Those of the 1st and 2nd classes only may be sent outside ordinary working hours. The following rules regarding their transmission require careful attention:—

I.—"Clear the line" messages are to be sent at once at any time, day or night, any other message being taken off for that purpose; they can only be sent by the individuals, and in the order of precedence as follows:—

(1) The Viceroy.
(2) The Commander-in-Chief.
(3) The General Commanding the Forces.
(4) Any other officer specially empowered.

II.—"Precedence" messages can be sent by the authorities noted above, or by persons in authority sending messages to them, or, if duly so franked, *vide* paragraph 6, they are to be sent at once, at any time, day or night, or as soon as a message under transmission is completed, and according to priority of receipt of their class.

III.—" State " or ordinary official messages, are to be sent according to priority of receipt during working hours.

IV.—" Private " messages, including Press, are to be sent according to priority of receipt during working hours, and after any State or Service message received has been sent. If franked as " Precedence " they come under Class II.

NOTE.—Messages regarding the telegraph line are to be sent in such precedence as their importance may seem to require.

6. The only officers who may frank messages as " Precedence," or for any other purpose, are the Assistant Adjutant General and Assistant Quartermaster General, or, if it be away from Division Head-Quarters, then the Officer Commanding Station, or Brigade, or his staff officer: the frank should be on each sheet and immediately in connection with terminal word of message.

7. All messages should be headed according to their class as noted above; the headings " Clear the line," or " Precedence, " being signed or initialled. The code signal for the same must also be given by the transmitting signaller.

8. Messages should be addressed to the place at which the addressee resides; they cannot be transmitted to railway stations where no Government telegraph office exists.

9. Messages should be condensed as much as possible, signed by the sender, and clearly written, especially as to signature.

10. Cypher messages can only be sent by one of the persons mentioned in paragraph 5, or if franked, *vide* paragraph 6. The part in cypher should be clearly so indicated as in cypher.

11. Private messages regarding the movement of troops or affording any information regarding the force are prohibited; any containing such intelligence, or anything at all of an apparently wrong or doubtful nature, are to be at once referred to the Officer in Command.

12. Signallers should not be required to write messages for the convenience of the sender. Forms and writing materials are kept in the office for public use.

13. Messages of such urgency as to require their being sent outside working hours (8 a.m. to 6 p.m. ordinarily) must be franked as " Precedence."

14. No message nor messages, including Press messages, aggregating more than 100 words, including addresses, may be despatched in one day by any individual as "private" or "Press messages," nor by any officer or department as "State messages," unless signed or franked, *vide* paragraph 6.

15. Press messages must be franked, for which they must be presented in person to the franking officer; they can only be sent to registered papers, and only to England by the correspondent of such papers registered by name. In all other respects they come under the rules for private messages. A list of correspondents so authorised should be kept in each office.

16. The telegraph line should not be used when the post will answer the purpose, or when they can be sent by heliograph.

17. Receipts are required for all telegrams issued from offices; they may be given on the envelope, or on a separate paper generally attached; they will only be given at the offices for telegrams given in for transmission, if demanded. Messages will be taken by messengers to the quarters, or the office of the addressees, and not after them, if absent, except under special circumstances. Officers should instruct their attendants to sign the receipts when they themselves are absent or unable to do so, as much waste of time may thereby be saved.

18. The signallers and other officials attached, having important duties, and being reduced to the fewest possible, should not be called away from their duties for any other purposes, such as holding horses, &c.

19. Messengers bringing telegrams from telegraph offices should not be detained more than a few minutes to take back telegrams.

Sufficient orderly messengers must be applied for by the Officer in Command, as the efficiency and utility of the telegraph line must depend very much on the prompt delivery of messages.

20. As a general rule the following scale may be considered as sufficient, subject to modifications as circumstances may require:—

2 infantry orderlies for a camp of one brigade or less.

1 additional for each additional brigade.

1 cavalry orderly or camelman (shutur sowar) additional for each division.

For a larger force, or where distances are great, additional men should be applied for. Arrangements should be made for their accommodation and meals, and also for their relief, so that these numbers may be always on duty; also that intelligent men may remain sufficiently long on this duty to be really useful.

21. The signallers or other officials of the Military Telegraph Train must keep all messages, official or private, secret. Any disobeying this order will be liable to trial and severe punishment.

22. The British soldier signallers will receive working pay on 1st and 2nd rates (Rs. 1, Rs. 0-12-0) on the same scale and under the same rules as for Royal Engineer soldiers attached to the Sappers and Miners, including the same liability to stoppages for neglect, &c.

23. A list of the qualified signallers attached to the force will be furnished to the officer in charge of the field telegraph train.

24. Signallers are to refer to the officer in charge of the field telegraph train any person applying for information with regard to the field telegraph, beyond what is contained in the above rules.

25. The field telegraph train is to be considered as attached to the Head Quarters of the force, and the officer in charge as attached to the general staff. When not required for telegraph purposes, he will generally be placed at the disposal of the Commanding Royal Engineer to rejoin the Sappers, or as may be found desirable.

26. Reference concerning the train will be made through the Commanding Royal Engineer of the force.

When working in conjunction with the civil line, there will generally be a military office close to, but separate from the civil terminus, messages being handed over.

## Report of Bridge at Safed Sang.

*From Lieut. W. Peacocke, R.E., Assistant Field Engineer, 1st Division Peshawar Valley Field Force, dated Camp at Safed Sang, 20th May, 1879, to Major-General Maunsell, C.B., R.E., Commanding Royal Engineer, 1st Division, Peshawar Valley Field Force.*

Sir,

In accordance with your orders verbally communicated to me, I have the honour to submit the following report on the bridge constructed by me over the Murki Khel Nullah, Safed Sang. I would wish to take this opportunity of bringing to your notice the very carefnl and energetic manner in which Sergeant Wade, 8th Company, Bengal Sappers and Miners, superintended this work, as also the highly satisfactory conduct of the Pioneer detachment, to which the successful completion of the work may be attributed.

I have, &c.,

W. PEACOCKE, LIEUT. R.E.

*Assistant Field Engineer* 1*st Division, P. V. F. F.*

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The Murki Khel runs along a bed one mass of large boulders, so that though little water now passes, the ford is not easy. Major Blair who reconnoitred it recommended a boulder causeway.

As no material for bridging was immediately available, the boulder causeway was commenced on the day that the advanced brigade, 1st Division, reached Safed Sang, and was completed and was further strengthened by an apron of heavy boulders, during the halt of the few following days. An immediate advance being improbable, advantage of the halt was taken to collect material for the construction of a bridge.

*Condition.*—The only timber procurable was scantlings of an average size of 16 feet by 3 inches by 8 inches, the wood being (presumably) that known as the 6-inch excelsa in India; wood of a very untrustworthy nature and useless, except when freshly cut. The bridge was to be capable of carrying the division, which included a 40-pr. battery.

*Description of Nullah.*—The drawing, *Plate* VIII., shows approximately the cross section of the nullah, which is considerably narrowed by the causeways of an old bridge, which consisted of two brickwork arches of about 90 feet span; the nullah slopes longitudinally about 200 feet in one mile; the bed of the nullah was irregular and stony, the depth of water varied from 3 feet to 0.

*Adoption of Trestles.*—The only point about which there could be question was whether crates or trestle piers should be adopted; I decided on using single trestles, as they could be more rapidly made and adapted to irregular bed, and as the scantling available appeared to me to be unsuitable for construction of crates, which latter would also much narrow the waterway.

*Preparation.*—While the timber was being collected and carried down from the hills by coolies, the causeways and approaches of an old bridge were ramped, and the remains of the central pier cut down by guncotton to suit the proposed height of the roadway of the bridge above water level, viz., 10 feet.

*Time.*—The actual construction of bridge occupied 10 days:—Extract from Brigade Orders, dated Safed Sang, 17th May, 1879: —No. 351. "The bridge, over the Murki Khel nullah, of 185 feet long, constructed by Lieut. Peacocke, Royal Engineers, commenced on the 6th instant, was finished on the 16th instant, and opened for traffic. (Signed) BERESFORD-LOVETT, *Major, R.E. and Brigade Major, R.E.*"

The time occupied in construction may appear excessive for a military operation, but I would beg that the following points may be noticed as a criterion of the difficulties under which the work was at all events commenced. On the first day, but a single carpenter (Corporal Luke, Royal Engineers), was available; only three on the second day. The numbers then gradually increased as the Sappers and Miners and Divisional Park arrived at Safed Sang. A single augur, and three small hand saws (two of these unexpectedly proved to be tennon saws), composed all the available carpenters' tools for the first few days, and during the same period not a single nail or iron dog was procurable.

The whole of the available establishment was employed in finishing Fort Sale, at Jalalabad.

*Construction, Road-bearers, Road Planking.*—The construction of bridge requires but small notice; each bay of 14 feet 6 inches consisted of seven road-bearers, arranged mainly for strength under the 40-pr. wheel tracks, though the extreme thickness of the road planking (which was of the same $2\frac{1}{2}$ to 3-inch scantling) must have equally distributed their load among the road-bearers. Each road-bearer was composed of two of the same 3-inch scantlings pinned together.

*Trestles.*—Each trestle consisted of four uprights, composed each of three 3-inch planks tree-nailed together, the central plank of each upright being continuous; while the outer planks supported the cap and the transom, which received the part of the struts of road-bearers. There was no ground sill, but the lower transoms were pinned on to the outside of the uprights, and the ends of the uprights cut to suit the irregular budding of trestles.

The method of erection was as follows :—

*Erection.*—As the bed of the nullah was prepared, each trestle, which had been prepared on the bank or the bed of the nullah, was carried, or floated into position and erected; a couple of planks were temporarily pinned to retain it in position when dressed, the down-stream strut was driven and secured to trestle, then road-bearers were laid and their strutting commenced; the road-bearers were each strutted individually and separately; the central straining piece having been previously pinned on to the under side of the road-bearer, the struts were then fitted and secured at the head, each by one iron dog; the feet of the struts rested on the top of the transom, and abutted against a piece of wood which was slipped in between the two pieces comprising the cap and the transom. I had anticipated some trouble in fitting the struts of the road-bearers, but was mistaken, as it was easily done, which was due to their not being framed as occasionally recommended.

The eastern half of the bridge required no strutting, as a sufficient number of girders for its road-bearers arrived at Safed Sang; these girders allowed of 20 feet spacing of the trestles, with a similar number (seven) in each bay; an abutment for the termination of the strutted portion of the bridge was afforded by the old central pier, half of which came into the line of the bridge in plan, and by bracing together the two half trestles, which, in the wake of the pier, carried the remaining half of the roadway in cross section. With the girders it was only necessary to prevent any possible deviation from the perpendicular of the trestles, by pinning a face piece to each outer road-bearer and side of trestle. The bridge, when finished, gave a roadway of 10 feet between the hand-rails, and was perfectly stiff. The roadway was finished off as usual with a layer of grass, 3 inches of elephant litter, and about 3 inches of earth. When completed a weight of 50 cwt. on one pair of wheels was rolled across, without any apparent effect as regards deflection or straining. As the first division never advanced beyond Gandamak, owing to the suspension of hostilities, the 40-pr. battery never crossed the bridge; but as the testing weight above so closely approximates to the weight carried by the hind wheels of the 40-pr. gun carriage, viz., 52 cwt., it may, I think, be fairly assumed that the defined conditions were satisfied. The rest of the 1st Division, including the field batteries, crossed the bridge on several occasions, and some thousands of baggage animals, such as laden camels, bullocks, &c., daily passed. With the exception of one mishap the bridge remained opened for traffic until the withdrawal of the troops from Safed Sang; though during the latter end of May nightly freshets occurred from melting snow. On the occasion referred to, the boulder causeway below the bridge broke, and all the water diverted into the breach, occasioning a heavy cross scour on one end of one trestle, causing it to sink at one side; the two bays of the bridge connected with this trestle had to be dismantled, another foot of the trestle sunk to restore it to its perpendicularity, and the consequent difference in level of the height of trestle, made up with several layers of planks on the top of the cap. The restoration occupied eight hours.

W. Peacocke,
*Lieut., R.E.*

This is a work of very high merit, both as a piece of engineering and as testifying to the energy and efficiency of Lieut. Peacocke, Royal Engineers, and the working party under him.

F. R. Maunsell,
*Commanding Royal Engineer.*

*Safed Sang, 20th May,* 1879.

Orders for Bridge.

Cavalry are to cross the bridge in single rank; Infantry to cross in file; two detachments of either may pass each other on the bridge. Field Artillery, including ammunition wagons, may cross either horsed, or by hand, as the officer in command chooses; they should be passed as nearly as possible along the centre of the roadway. Laden pack animals are to cross in single rank and in one direction only at the same time. No riding or unladen animals may pass them on the bridge. Mounted riders, also unladen pack animals, may pass each other on the bridge in single rank.

2. The Infantry "rule of the road" is to be observed as far as possible, *i.e.*, the passing is to be left arm, each moving with the right arm next the bridge railing.

3. In case of a block on the bridge, all traffic on the bridge is to be stopped until it is clear.

4. These rules as to the lines of traffic are to hold good over the causeway to the bridge, or up to points indicated by the Engineer officer in charge, as well as on the bridge itself.

Note.—The bridge has been tested to 50 cwt. on one pair of wheels. Roadway is 10ft. wide.

(Signed) F. R. Maunsell, *Major General, C. R. E.*

*Safed Sang, 20th May,* 1879.

## Picquet Posts, Dakka.

*Camp Jalalabad, 28th January* 1879.

Memorandum.

It was necessary to occupy the small hills immediately outside the north face of Dakka Fort, as they commanded the interior of that fort. (See *Plates* II. and III.)

It was proposed to effect this by constructing five picquet posts along these hills, tenable by small picquets, and practically safe against a sudden rush. The situation of these is shewn on a general plan submitted before, and their details are now given in the accompanying sketches. (See *Plates* IV. and V.) All have been constructed, except Redoubt No. 2, which is required to complete the system. All have guard houses, giving comfortable shelter to the picquets.

It is believed that with picquets of the following strength they will be secure :—

| | |
|---|---|
| N. E. Post ... ... ... ... | 20 men. |
| No. 1 Redoubt ... ... ... | 15 „ |
| „ 2 „ ... ... ... | 15 „ |
| „ 3 „ ... ... ... | 15 „ |
| Picquet ... ... ... ... | 15 „ |
| Total ... | 80 men. |

This is not an excessive number to guard, as I believe very satisfactorily, a front of about half a mile.

Two other picquet posts were made by the Sappers at Dakka. One in the Kurd Khaibar pass, and one on the conical hill about a mile south-west from the fort. These merely consisted of breastworks of stone, with a guard house.

(Signed) W. North, *Captain,*
*Commanding Sappers and Miners.*

The positions for these posts were well chosen by Captain North, and they are good specimens of such works.

(Signed) F. R. Maunsell, *Major-General.*

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## Report of Rafting Operations from Jalalabad to Dakka.

*Original, dated 16th June,* 1879, *submitted to the General Commanding.*

On the retirement of the 1st Division from Safed Sang and Jalalabad, the Commanding Royal Engineer was directed to arrange for rafting the Engineer Park and stores from Jalalabad to Dakka, 40 miles; all to be cleared off in ten days.

2. Orders were at once sent to the garrison engineer of Jalalabad to take all the necessary steps to push forward the preliminary arrangements, moving down to the river banks timber for rafts, etc., and Aboo Khan, timber agent, was directed to take up the rafting; but, as it was found that he had also contracted with the Commissariat Department for rafting stores, other arrangements to avoid clashing and to expedite matters, were made.

3. On the 2nd instant the Commanding Royal Engineer with Major Blair, Royal Engineers, also two Companies of Sappers, one Bengal and one Madras, arrived at Jalalabad. During that day the Bengal Sappers and Line working parties were employed in carrying down timber and Park stores (the Madras Sappers having received orders to move on at once). Arrangements were made also for the construction of rafts of timber, of mussacks, of empty beer barrels, and of ghi dubbas: the demolition of some of the sheds in Fort Sale was also commenced, for the sale of the wood useable in rafts. Two wharves for depositing stores and for embarkation were fixed at some distance apart. One (the upper) for Engineer Park, telegraph and ordnance stores, and the other for Commissariat grain and other food supplies, &c. The lower or Commissariat wharf was left entirely to the Commissariat stores and arrangement, until all the other stores had been despatched.

4. On the 3rd instant, the first transmission from the upper wharf took place: a boat laden with stores and containing several officers was despatched, but, owing to its unmanageable size and the want of experienced navigators, it grounded at Ali Boghan, and the contents had to be subsequently sent forward on skin rafts.

5. On the 4th, the regular transmission of rafts may be said to have begun and to have continued regularly up to the 13th, by 8.30 a.m. of which date the whole of the stores were despatched, nothing being left in the fort but a stack of firewood. During these days some 7000 skins were used, besides a quantity of timber and some 25,000 maunds of stores were transmitted. On each raft one or more Sappers were sent as a guard, and in this manner two companies, also all the Pioneer workmen, were despatched to Dakka; it was also found feasible to thus send down a large number of native sick, including the cholera patients. A number of officers and soldiers were also sent.

6. The Commanding Royal Engineer endeavoured to aid, and to hurry on the Commissariat Agent, Aboo Khan, but it was very evident that he could not cope with the business, and indeed seemed

to wish rather to delay it, saying that he was ready to take the responsibility of sending down all the stores after the troops had left. He also adduced several causes for the delay and difficulties occurring, as that he had not ready money enough, and no one to help him, and that the engineer's operations interfered with his, &c.

The number of rafts he sent off from his wharf was very far below that sent from the upper wharf. Yet there were sometimes rafts remaining unemployed, just because he could not or would not come to terms with the raftsmen; it was evidently a matter of ready cash; for the payment he said he was promising was half as much again as that made at the upper wharf; only there the money was promptly paid. There can be no doubt that there were plenty of rafts, and that in better hands all the stores would have been cleared off by the 10th.

7. As then it seemed hopeless to get these stores off by the time required, arrangements were made by the Commissariat Department to store 9,000 maunds of grain in the fort, to be made over to the Amir.

8. It was not till the night of the 10th, that it was finally decided that none of these stores should be left in the fort, and that the march of the rear guard should be postponed to enable them to be sent off. Arrangements were at once made to carry out these orders, and every effort made to complete the transport during the 11th and 12th instant, so as to allow the rear guard to march on the 13th. The morning of the 11th was chiefly taken up in rafting off Division Head Quarters' staff, and numerous other officers, and some time was also lost in recalling a number of the raftsmen who had been dismissed; but a good number of rafts were despatched and by the afternoon the work was in full swing; the available land transport was employed in reliefs all day, with strong working parties to load and unload.

9. With a view to encourage the men and quicken their movements, each working party was granted a free tot of rum; and so well did these men work—men of the 27th and 45th Native Infantry—that before night the whole of the stores actually required to be sent off were deposited at the wharves. As the rafting arrangements seemed likely to admit of everything being sent, the remaining deadstock of all sorts was similarly deposited the next morning, *i.e.*, on the 12th.

10. Although a tolerable number of rafts were also sent from the lower wharf, it was found impossible to embark all these stores

before the 13th, but owing to the efforts made by all, the preparation of rafts going on all night, everything was cleared off by 8.30 a.m. on the 13th, so that the rear guard was enabled to march the same day.

11. The obligatory point being to embark the stores within a certain time, it was not possible to keep an accurate account of the load on each raft, and it was necessary to trust to the disembarkation arrangements at Dakka, but it is believed that no loss except a little wetting of some food stores was incurred. No loss to the Engineer stores occured.

The account of the rafting is as follows :—

| | Rs. |
|---|---|
| 184 skin rafts, of from 15 to 60 skins in each, costing for hire, Rs. 2-8-0 per skin; average number of skins per raft 36. Total cost ... ... ... ... | 16,560 |
| Total skins between 7 and 8 thousand; 5 rafts of casks, pontoons, dubbas, costing per hire of boatmen each 20 Rs.; total ... ... ... ... ... | 100 |
| 36 rafts of timber, ditto ... ... ... ... | 730 |
| Grand total... ... ... ... | 17,380 |

885 officers and soldiers, including 339 sick, were also rafted.

The stores were:—Engineer, ordnance, medical ambulance, civil and military telegraph, commissariat food and dead stock, camp equipment, &c.

### Memoranda concerning Bullock Skin Rafts.

*Original, dated July,* 1879, *submitted to Quartermaster General.*

With a view to assuring myself of the process of arranging the skins, tanning them, &c., I had one prepared before me, from the killing of the animal to the final completion of the skin. Bullocks are used nearly invariably; a horse skin is sometimes seen; bullocks being sufficiently large and more common; skins of goats or sheep are not large enough.

It took about three hours to skin the animal and render the skin fit to be used, though not completed; three days more rendered it complete. The tanning was effected by salt and powdered pomegranate fruit rind; a little oil finally improves it, but is not indispensable.

The bark of the babool mimosa serves as well for tanning, but is not so easily obtained, and the pomegranate powder seems so conveniently carried; the powder plastered over the skin saves the need of a vessel.

The skins can be folded up together and some dozen carried by a man.

The superstructure is made of griddles of battens lashed with string.

Rows of skins are laid together, heads all in one direction, to make up the width of the raft, and lashed, very much as for barrel piers. These piers are again ranged together and lashed across into one complete elastic whole, about square; with a final row or line of skins running round the whole broadside, or heads following tails.

At each of the four corners is fixed a strong rowlock, three feet high for rowing and steering; add four oars about sixteen feet long and four oarsmen, and the raft is complete.

Before being used the skins are steeped in water for two or three hours, then blown out: any weak points caulked with shreds of cloth or linen, and a bradawl. They are generally steeped over night and blown out in the morning.

The filling them is done direct by the mouth, blowing into one of the leg pipes, or into a pipe inserted therein, or by a small goat skin bellows kept for the purpose. After being formed into a raft and especially when loaded, they require filling up from time to time.

A tolerable sized skin may be counted as for a buoyancy of some $2\frac{1}{2}$ or 3 maunds in rafts, say 200lbs. A skin lasts perfect one year, and imperfect filled with rushes, with half buoyancy, two years more.

Rafts vary from sixteen to sixty skins.

It takes about an hour to put together twenty skins.

The chief difficulty and delay was for oars and rowlocks; carpenters were also needed for expedition, but the natives can work rough carpentry themselves.

The strength of these skins is surprising. One raft of sixty skins, laden with grain, was dragged by main force (some forty men round it to haul) over some thirty feet of ground without being damaged.

Every man in every river village seems to have a dozen or so of these skins, and they are very adept in putting them together.

I was greatly impressed with their utility and adaptability to our use, their facility of transport, and, indeed, the fact of our driving them with us alive for food, providing an inexhaustible store, adds a strong point in their favour.

## UNDERGROUND WATER-COURSES OR KAREZ.

The peculiar and very successful system of subterranean canals, so general in Afghanistan, deserves special notice.

These water-courses have been long common throughout Persia, and the adjoining countries: they were even met with in Cyprus.

The extreme dryness of the climate, which would induce loss by evaporation and absorption of all the water, and the scarcity of running water, renders this expedient most suitable. They are termed karaiz, or kahreez, or kanats.

Several shafts are usually sunk, at different depths, where water is believed to exist, and, when a supply is obtained at a suitable depth, the shafts are connected and their united waters conveyed in one stream towards the surface at the required level.

The spot is determined where the water shall issue on the surface, and thence, at regular intervals of twenty or thirty paces, a series of shafts, about $3\frac{1}{2}$ feet diameter, are sunk, towards the source. When these have been dug to the intended level, they are connected by galleries, of about the same sectional size as the shafts, to convey the stream, both shaft and galleries seldom having any artificial support.

It was stated that it is usual to construct a small water flow on the surface, from which the depth of each shaft is measured.

They run sometimes as far as twenty miles, before reaching the surface. The practice of making them seems to be confined to certain families; practice makes them certain, and failure seldom occurs.

Whole villages depend on these streams for water, both for drinking and for irrigation; mills are also worked by them.

They are said to have been first constructed by King Houshung, grand uncle of Jewsheed, anterior to the time of Zoroaster.

The buildings and system of working in the country deserve some notice.

Building with burnt bricks and mortar is hardly known; the houses and walls are of sun-dried bricks with mud cement, or a sort of pisé and mud, which seems to last wonderfully, after it is once dry: the mud is stirred up and trodden into a good consistency, far more thoroughly than is done for such work in India: it is then chucked from hand to hand along a row of five or six men, giving it a further manipulation, and it is finally dabbed down on the wall; some eighteen inches high is thus built at a time, and left to dry. All the defensible walls of towns and forts are thus made: the mud is sometimes mixed with straw. I do not think the suitability of this pisé is confined to Afghanistan.

A convenient method of moving quantities of loose earth a short distance is adopted, namely—large rakes with a board instead of prongs.

A very common sort of shelter consists in excavations of from five to eight feet deep: roofed over, with low wall. The Amir's troops seem to have freely used these dwellings; they are warm in cold weather and cool in warm.

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## Report on the employment of the Head Quarters, Bengal Sappers and Miners, attached to the 1st Division, Peshawar Valley Field Force (Khaibar Column) throughout the Afghan Campaign 1878-79.

The Head Quarters of the Corps, with the 2nd, 3rd, 6th and 8th companies joined the force at Jamrud on the 19th November, 1878. The Companies were considerably below their strength owing to sick, &c.

*Khaibar Pass.*—On the morning of the 21st November, the whole paraded with the rest of the force for the attack on the Khaibar, with engineer equipment on mules. The 6th and 8th Companies, with Corps Head Quarter Staff, proceeded with the van guard (500 infantry) of the advanced guard of the attack; the 2nd and 3rd being ordered to remain improving the road near the mouth of the pass. The advanced Companies were employed throughout the day in improving the way, which was found in many places impassable, and rendering it passable for artillery; also in dragging the guns up. I am justified in reporting very highly of the Sappers' work on this day, work, a great part of which was done under a sustained artillery fire. Lieutenant and Adjutant S. H. Exham and Sergeant Major Chesney are entitled to special mention for their energy and example.

For the night of the 21st instant, when the force bivouacked in front of the Ali Masjid position, the Sappers took the picquet duty on the left flank.

In the morning they were the first troops to enter Ali Masjid Fort, which was only being evacuated by the last of the enemy as they entered. Throughout the 22nd and next night they had severe guard and picquet duty, being in advance of the rest of the force.

During the next two days they were employed with the advanced guard in advancing through the Khaibar and making the way passable for the Horse Artillery. In some instances our men had to drag the whole battery over the bad parts.

In addition to hard work throughout the day, there were heavy picquet duties each night, and little food for these first four days of the campaign. All ranks behaved admirably throughout.

*Dakka.*—The Corps reached Dakka on the 26th November, being joined next day by the 2nd and 3rd Companies. It remained at Dakka until the 17th December, being employed constantly at work, strengthening and draining the fort, making defensible posts, &c., and also on the Abkhana road. Some good experience was gained in road-making, and also in choosing ground for posts and constructing them.

*Jalalabad.*—The Corps, with the advanced part of the force, reached Jalalabad on the 20th December, leaving the 2nd and 8th Companies to continue the works at Dakka and the Abkhana road. The 2nd Company rejoined headquarters at Jalalabad on the 29th December, the 8th Company remaining in garrison at Dakka. At Jalalabad the work was throughout constant and very varied—making fortified posts, throwing a trestle bridge across the Kabul river, drainage, road-making, &c., and latterly helping at the construction of the large " Fort Sale." During portions of the time the 6th Company was exclusively employed on telegraph work. As this was carried on under the Commanding Royal Engineer direct, I will only say that it was very hard work, and done, I believe, entirely to his satisfaction.

*Girdi-kas.*—On the 20th January, 1879, the Head Quarters and 2nd and 3rd Companies left for Girdi-kas to construct the alternative river route. They were employed on this continuously until the 19th March, when they returned to Jalalabad. They were joined on the 19th February by the 8th Company from Dakka. This was the largest work the Corps had during the campaign, about 8 miles of most difficult road-making, in parts through the hardest rock and by precipices. It was far the hardest road-making attempted in the campaign. It was most creditable that in less than two months a good artillery road should have been made where before not a goat or a mule could have passed in places. The Corps was helped for a time by 100 men of the 17th Foot, who worked splendidly; also, by some Native Infantry and country coolies, who worked badly, and were useless except for the easier portions of the road.

Great experience was gained on this work, especially in blasting, both with guncotton and gunpowder. A memorandum on this subject is attached.

While detached at Girdi-kas the Corps was more than once threatened with an attack by the enemy. One afternoon about 5000 of these, with some cavalry, appeared across the river about a mile off (the river being fordable), with the apparent intention of attacking. As the Sappers were only 150 strong at the time, it was thought prudent to shift camp to a previously selected spot, and intrench. In about three hours a most satisfactory post was formed; no attack was, however, made.

On return to Jalalabad the same work generally was carried on as before.

*Safed Sang.*—On the 30th of April the Corps marched for Safed Sang, Gandamak, where it remained until the end of the campaign employed in making the fort road work, &c.

*Expeditions.*—Sections, or Companies of the Corps accompanied every one of the many expeditions against hostile tribes which took place during the campaign. The 8th Company, under Lieutenant H. P. Leach, had the good luck to come in for most of these. They were invariably most successful, and a large number of demolitions of towers, the chief engineering work the Sappers were called on to perform in these expeditions, took place. The Sappers, when they were allowed to, also acted most efficiently as light infantry on these occasions.

*Miscellaneous.*—The photograph school accompanied the Corps throughout, and a number of views, &c., were taken, which appear to have been generally appreciated.* There was some want of energy in this department at first, but it afterwards worked satisfactorily.

Lieutenant G. W. Bartram made a number of sketches, which have since been photo-zincographed. (See *Plates* IX., X., and XI.)

The following memoranda are attached :—

1. General remarks on the requirements of the Corps.
2. Memorandum regarding general service equipment (no mention is made of special equipments, such as telegraph and bridging, these have been or will be fully dealt with elsewhere).
3. Remarks regarding guncotton and gunpowder experience.

In conclusion I wish to state that all ranks did their duty thoroughly well throughout. The officers are deserving of special mention for their eagerness and efficiency.

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* These views were shewn at the Annual Exibition of Photographs in London, 1879.—Ed.

*Regimental Staff Officers*:—

| | | |
|---|---|---|
| Lieut. G. W. Bartram, | ... | Superintendent Park. |
| „ S. H. Exham, | ... | Adjutant. |
| „ E. Blunt, ... | ... | Instructor Telegraphy. |

*Company Officers*:—

| | | | |
|---|---|---|---|
| 1st | Company— | Lieutenant | C. Maxwell. |
| 2nd | „ | „ | J. C. Campbell. |
| 3rd | „ | „ | H. Dove. |
| „ | „ | „ | *Hon.* M. G. Talbot. |
| 6th | „ | „ | W. F. H. Stafford. |
| „ | „ | „ | A. R. Ancrum (since dead). |
| 8th | „ | „ | H. P. Leach. |
| „ | „ | „ | R. V. Phillpots. |

Mr. Conductor James Grant, Sergeant-Major Hawkins (died of cholera on return march), and Sergeant-Major Chesney, are also deserving of special mention. Subadar Hyder Shah, a very distinguished and able native officer, died of cholera at Jalalabad ; his loss has been a serious one to this Corps.

In the list of officers I have given, all of whom deserve that some record of their good service should be kept, are not included the officers of this corps who served with companies of the corps in other columns in the campaign. The 7th Company served with the Kurum Force, and the 4th, 5th, 9th and 10th with the Kandahar Force. I make no mention of these here, as they were not under my immediate command during the campaign, and I have not yet received their final reports.

(Signed), W. North, *Captain R.E.*,
*Commanding Bengal Sappers and Miners.*

*Roorkee, 27th August*, 1879.

General Remarks on the Requirements of the Bengal Sappers and Miners.

The experience of the late campaign has not changed our opinions regarding the requirements of the Corps. The meterial (arms, accoutrements, dress, camp equipage, and engineer equipment) is admirable and well adapted for all service. It would perhaps be convenient, as our companies are at all times liable to be so much broken up, if our half sepoys' tents were altered so as to form lascars' pals, otherwise I have no suggestion of importance to make. There are of course minor ones to make.

The wants in the personnel however (in which transport animals are included) have made themselves as much felt as ever. There is nothing new to remark on these, but I will enumerate them—

1. *British Officers.*—There happened to be a fair number of experienced officers with the Corps when the campaign broke out, so no inconvience was felt. This, however, under present conditions, may not happen again.

2. *British Non-Commissioned Officers.*—Many of these are excellent but a number are unfitted, from their attainments, to be non-commissioned officers of this Corps. If good men could be obtained, I would by no means recommend that the present numbers should be reduced, but I believe that a system, which would secure the services of two really efficient non-commissioned officers per Company, would be better than the present one, which provides six, all of whom may be inefficient.

3. *Natives.*—I believe there is no question but that there should be a greater number of Sepoys in each Company, say 150, with a proportionate increase of native non-commissioned officers. For frontier work natives of the Punjab and Trans-Indus are more suited than the natives of Hindustan, from which we have to obtain five-eighths of our recruits, on account of the difficulties the latter give about water. They are also generally (the former) of stronger physique.

4. *Company Artificers.*—These get very low pay and no pension, though they have as hard service as the combatants, and accompany them everywhere. In consequence we get a very inefficient class.

5. *Transport Animals.*—Our shortcomings regarding transport of engineer equipment at the beginning of the campaign were most marked: at the end, after constant practice, the men were highly efficient. The same inefficiency would be felt at the beginning of the next campaign, if we are not allowed to keep mules permanently with each company in cantonments. We have asked for 12 per company, with a mule driver to each, and a certain number, 60 in all, (but not the mule drivers) have been already sanctioned as a temporary measure. I hope all will be soon, and permanently.

With the assistance of Lieut. L. F. Brown, and other experienced officers, it is hoped soon to have a very serviceable equipment, and system of exercise, worked out for these general service mules.

### Memorandum regarding the General Service Engineer Equipment of a Company of Bengal Sappers and Miners.

This, as recommended in 1870, and sanctioned, and weighing 100 maunds, is most complete. After our further experience of the last ten years there are few modifications to propose.

When heavy road work in rock is required, the mining tools are not sufficient, but these should be obtained, only when required, from one of the reserve Parks. I may remark that the Company smiths are so bad (owing to the low rate of pay allowed) that they are quite unable to keep the tools in proper repair when blasting is going on.

It is not, of course, necessary, nor desirable, nor possible to take the whole equipment of 100 maunds with a Company on all occasions, such as on an advanced guard or raid, or even an ordinary rapid expedition. It is considered that 12 mule loads of equipment (about 24 maunds) on good trained mules, with a driver to each, should generally accompany each Company into action, and on almost all occasions the rest of the equipment, or as large a portion of it as may be considered necessary, following with the baggage, or later, on such carriage as may be feasible.

The following is given as a suitable equipment for a general service company for rapid operations of about a month's expected duration. (This was actually sanctioned for the advance on Kabul from Gandamak, had it taken place.)

12 mules, 24 maunds, with Company.

4 camels, 16 maunds, to follow with baggage.

*Mules.*

| | | |
|---|---|---|
| Nos. 1, 2, 3, 4, 5, 6, } mules | 8 sets pick and shovel | 120 lbs. |
| | 2 mamooties ... | 15 |
| | 1 pr. kajawas ... | 28 |
| | Total ... | 163 |

| | | |
|---|---|---|
| No. 7 mule— | 100 ft. Bickford's fuzes ... ... | 12 |
| | 10 Hand grenades, loaded ... ... | 20 |
| | Match, quick and slow ... ... | 2 |
| | Powder measures and funnel ... | 6 |
| | 1 Bullock pawlin ... ... | 10 |
| | 10 Port fires and sticks ... ... | 4 |
| | 15 Jagged spikes ... ... | 2 |
| | Country twine (or other) ... ... | 5 |
| | Vesuvians ... ... ... | 1 |
| | 1 pr. Mule boxes ... ... | 60 |
| | Total ... | 122 |

| | | | |
|---|---|---|---|
| No. 8 mule—4 Bags powder ... | ... | ... | 120 lbs. |
| 1 Bullock pawlin | ... | ... | 10 |
| ... | Total | ... | 130 |
| No. 9 mule—2 Crowbars, $2\frac{1}{2}$ft. | ... | ... | 20 |
| 3 ,, $4\frac{1}{4}$ft. | ... | ... | 78 |
| 3 Jumpers, $4\frac{1}{4}$ft. | ... | ... | 60 |
| Tamping bar, needle, &c. ... | | ... | 9 |
| | Total | ... | 167 |
| No. 10 mule—2 Sledge hammers | ... | ... | 32 |
| 3 Felling axes ... | ... | ... | 26 |
| Wedges ... | ... | ... | 12 |
| 2 Drag ropes, heavy | ... | ... | 38 |
| 2 ,, light | ... | ... | 32 |
| | Total | ... | 140 |
| No. 11 mule—8 Felling axes ... | ... | ... | 68 |
| 3 Saws ... | ... | ... | 3 |
| 10 Sickles ... | ... | ... | 10 |
| 10 Kookeries ... | ... | ... | 20 |
| 8 Gabion knives | ... | ... | 2 |
| Moonge ... | ... | ... | 40 |
| 1 Bullock pawlin | ... | ... | 10 |
| | Total | ... | 153 |
| No. 12 mule—150 fathoms Rope, Europe, $1\frac{1}{2}$-inch | | ... | 78 |
| 90 Sand bags, (light) | ... | ... | 67 |
| 1 Bullock pawlin | ... | ... | 10 |
| | Total | ... | 155 |

*Camels—(to follow).*

| | | | |
|---|---|---|---|
| No. 1 camel—Field forge ... | ... | ... | 80 |
| Assorted smith's tools in mule box | | ... | 80 |
| ,, carpenter's ,, | | ... | 80 |
| Steel, iron, nails and screws | | ... | 80 |
| | Total | ... | 320 |

| | | |
|---|---|---|
| No. 2 camel—Charcoal | ... ... ... | 320 lbs. |

| | | |
|---|---|---|
| No. 3 camel—Spare helves | ... ... ... | 80 |
| Lantern with candles | ... ... | 5 |
| 2 hand reels with lines | ... ... | 5 |
| Surveying instruments with paper | ... | 20 |
| Linen, needles and thread ... | ... | 10 |
| Rope, 3-inch, 130 fathoms ... | ... | 200 |
| | Total ... | 320 |

| | | |
|---|---|---|
| No. 4 camel—6 Jumpers | ... ... ... | 126 |
| 6 Hammers | ... ... ... | 96 |
| 4 Crowbars, $4\frac{1}{4}$-inch | ... ... | 68 |
| Hand spikes | ... ... ... | 30 |
| | Total ... | 320 |

NOTE.—Some guncotton, with apparatus, should be added to the above equipment, but I am not yet prepared with a detail of this.

If a demolition party only, and not a Company, nor section of a Company, is required to accompany a force, the following, drawn up by Lieutenant G. W. Bartram, Royal Engineers, has been approved for the present.

The party to consist (under an officer) of—

2 British non-commissioned officers;
2 Native ,,
10 Sepoys;

to be divided into two sections, each of 1 British and 1 Native non-commissioned officer and 5 Sepoys.

Each section to be accompanied by three mules, with detail of equipment as noted below:—

| | | |
|---|---|---|
| No. 1 mule—Powder in leather bags, | ... ... | 150 lbs |
| Sand bags 6 | ... ... ... | 3 |
| | | 153 |

| | | | |
|---|---|---|---|
| No. 2 mule—Mining picks | ... ... | 2 ... | 11 |
| Shovels | ... ... | 2 ... | 7 |
| Push picks | ... ... | 2 ... | 2 |
| Crow bars | ... ... | 2 ... | 14 |
| Hatchets | ... ... | 2 ... | 4 |
| Saws, small | ... ... | 2 ... | 2 |

| | | | |
|---|---|---|---|
| Adzes | ... | 2 | ... $7\frac{1}{2}$ lbs. |
| Bickford's fuze, 100 ft. | ... | | |
| 1 Gabion knife | ... | | |
| 1 Powder measure | ... | | |
| 1 Funnel | ... | | |
| String | ... | | |
| Ratline | ... | | |
| Spikes | ... | | $112\frac{1}{2}$ |
| 1 Hammer | ... | | |
| 1 Gimlet | ... | | |
| Vesuvians | ... | | |
| Rope ladder | ... | | |
| Pair of mule boxes | ... | | |
| Total (No. 2 Mule) | ... | | ... 160 |

| | | | |
|---|---|---|---|
| No. 3 mule—Picks | ... ... | 5 | ... 50 |
| Shovels | ... ... | 5 | ... 29 |
| Crow bars | ... ... | 2 | ... 34 |
| Axes | ... ... | 2 | ... 20 |
| | | Total | ... 133 |

NOTE.—For extended operations, more No. 1, or powder mules, would have to be added.

The above is specially adapted for demolitions of forts and towns in Afghanistan, and might have to be modified.

Fifty lbs. of powder was the charge generally used to demolish a tower; it invariably accomplished its work thoroughly.

NOTE.—The towers were nearly all of similar form, but varying in dimensions, generally solid to nearly half their height: the solid part being boulders with layers of wood and sticks at intervals of 2 or 3 feet. The powder was usually found to be best placed in the solid portion, from above 5 or 6 feet down, and tamped with clay, taking one hour to effect. Hasty demolition is ensured by 100 lbs. buried under the floor. (From Lieutenant Bartram's Memo.) F.R.M.

*Memorandum on Guncotton and Gunpowder.*

*Demolitions.*—Owing to want of detonators when the opportunity occured, only one tower was demolished by guncotton; eight lbs. did this thoroughly, lodged in 2-lb. charges at each corner of the base; we should have used 50 lbs. of gunpowder to demolish the same tower.

If some practice in demolitions of this kind could be had with guncotton, there is little doubt but that it should entirely take the place of gunpowder, on account of the great saving of weight to be carried (most important in raids in the hills,) and also, a great saving of, I believe, half the time in lodging the charge. I see no chance of any practice, however, except in presence of the enemy (of which we have had plenty); and on such occasions the General officers in command are so anxious to have the demolitions completed and the force withdrawn, that we cannot make experiments, and have to use gunpowder, the certain effect of which we know.

As far as I can see, Bickford's detonators only should be used for guncotton demolitions of this kind.

The demolitions of towers we made were almost invariably made in the same way, by sinking 50lb. of powder, in sandbags, in the centre of the base of the tower, and firing with Bickford's fuze. The result was invariably completely successful. Time about $\frac{3}{4}$ of an hour.

It is important to have vesuvians to fire Bickford's fuze.

*Blasting in rock.*—For blasting in rock, guncotton seems altogether superior to gunpowder. For blasting out of solid rock after boring, the time taken for tamping is saved by using the latter, and the effect seems greater.

For detached pieces of rock which have to be got rid of, there is no comparison. These, of great size, and which it would take days to bore and get rid of with gunpowder, are smashed up at once by slabs of guncotton simply laid on the top and exploded.

The guncotton should always be laid on the top surface of these detached rocks. For some reason, which I cannot explain (it is not because its contact with the rock in the former case is more perfect), an altogether inferior effect is produced when the guncotton is applied to the side of a detached rock, or its bottom surface, if that is exposed.

For explosions of this kind, electric detonators, with tension machines, appear most suitable.

Very successful use of large charges of gunpowder, up to 150 lbs., was made on the Girdi-kas road; when advantageous fissures in the rock were found.

As far as I am able to judge, there is much less likelihood of accident with guncotton than with gunpowder.

(Signed) W. North, *Captain, R.E.,*
*Commanding Bengal Sappers and Miners.*

*Roorkee, 27th August,* 1879.

(Signed) F. R. Maunsell, *Major General,*
*late C.R.E., 1st Division P. V. F. Force.*

ON PESHAWAR VALLEY FIELD FORCE. **Plate I.**

# PAPER XII.

# TARGETS

FOR THE

# TRIAL OF RECENT BATTERING ORDNANCE.

By Colonel T. Inglis, R.E.

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## Part V.

In Paper XIV., Volume II., this subject was reported up to the autumn of 1878, the last trial there noticed being that in which a 6-inch rifled breech-loading gun of new design gave very promising results.

Following the order of the armour plate experiments which have since taken place, the further performance of this gun will now be mentioned.

### 6-Inch Rifled Breech-Loading Armstrong Gun against Armour.

The gun used in these trials was briefly described in the Paper above quoted, but since closing the experiments at armour the pattern of this gun, principally as regards its length, capacity of chamber, and its ammunition, has been somewhat modified, and it may therefore, perhaps, be better that I should give some particulars of the gun in the form in which it is likely to be introduced into the service rather than continue the description of the original gun as it was in its experimental stage.

The gun is constructed generally on the Woolwich principle, except that the steel tube is so far thickened that it forms of itself the chase of the gun without the help of any wrought iron coils.

The calibre of the gun is the same as before, viz :—6-inch, with a chamber $7\frac{1}{2}$ inches in diameter, and $27\frac{1}{2}$ inches long. Its nominal weight is 4 tons, its total length is 13 feet 9 inches, and the bore is 26 calibres long. The rifling is polygrooved (28 grooves) with a twist increasing from 0 at the breech to 1 turn in 40 calibres. The breech mechanism is on the French interrupted screw principle, with the Elswick expanding steel cup, called the obturator, to seal the breech. This cup, or rather saucer, is flat bottomed, and is secured by a bolt passing through its centre to the inner end of the breech screw, with the cup side turned towards the powder charge. The end of the breech screw against which the bottom of the cup bears is not flat, but slightly convex; when, therefore, the powder gas presses backwards against the cup the bottom of it takes the form of the convex end of the breech screw, and this necessarily throws the rim or lip of the saucer outwards against the circumference of the bore, or rather against a copper ring set in the bore, and so effectually prevents the escape of gas round the breech screw. When the pressure on the cup is relieved it returns to its normal state. The gun is vented through its breech screw.

The battering projectile weighs 80 lbs. and is rotated by means of a copper band on its base, there being no studs on the shell. The battering charge will probably be 34 lbs. of P powder which will give a velocity at the muzzle of about 1,930 feet per second, reduced to 1,600 at 1,000 yards range, the energies corresponding with these velocities being respectively 2,070 and 1,415 foot-tons.

The gun was mounted on an ordinary double plate carriage and slide, with plate compressor gear to check recoil.

From the results obtained with the experimental gun it may be laid down with tolerable certainty that if the service gun fires 34 lbs. P powder it will be capable of perforating unbacked rolled iron armour of good quality in direct fire at the following ranges :—

At the muzzle it will perforate about 11 inches of iron.
,, 1,000 yards ,, ,, ,, $8\frac{3}{4}$ ,, ,,
,, 2,000 ,, ,, ,, ,, 7 ,, ,,
,, 3,000 ,, ,, ,, ,, $5\frac{3}{4}$ ,, ,,
,, 4,000 ,, ,, ,, ,, 5 ,, ,,

In some comparative trials between steel and chilled cast iron projectiles from the experimental gun, there appeared to be but little difference between them as regards either perforation of iron plates which were not quite a match for the gun, or indents on plates which were more than a match for the gun, but in every instance the forged steel shell remained entire and generally without any cracks, after delivering the blow, even when striking with a velocity of 2,050 feet per second, whereas only three chilled iron shell remained entire out of 17, the highest striking velocity in these three cases being 1,026 feet per second.

Cast steel shell from this gun did not do so well as forged steel shell, as regards either their effect upon the armour, or their tenacity.

The trials of this gun were further utilized in experiments that were intended to set at rest the old question, whether projectiles of the same diameter and similar form, but of different weights, will effect equal penetration, provided they strike with equal energy, assuming of course that they are all sufficiently hard to avoid much change of form.

For this purpose shells of 60, 80, and 100 lbs. were used in three separate series, in which the velocities were adapted to give uniform energies of about 1,080, 1,800, and 1,900 foot-tons respectively. The result was that in every series the lightest shell produced the least effect upon the armour, and that, on the whole, the medium weight was slightly superior to the heaviest, when they struck with equal energy.

These trials show the importance of arriving at a law for the determination of the best weight of battering projectile for every nature of gun, and in close connection with this subject there is the important consideration that the heavier the shot the longer will be the range of equal penetrative effect.

## 8-Inch Rifled Breech-Loading Armstrong Gun against Armour.

As a matter of fact it was not the new breech-loading gun of this calibre that was tried against armour, but one of similar dimensions and power made for muzzle-loading. It may be more convenient, however, that the breech-loading gun should be described here, and its performances deduced, as they may safely be, from the results obtained with the other gun.

The breech-loading gun then is made generally on the same principle as the 6-inch, above described, and has similar breech closing mechanism. The calibre of the bore is 8 inches, and the chamber is 10 inches in diameter, and $43\frac{1}{2}$ inches in length. Its nominal weight is $11\frac{1}{2}$ tons, its total length is $18\frac{1}{2}$ feet, and the length of its bore is 26 calibres. The rifling is much the same as that of the 6-inch breech-loading gun. There are 33 grooves, and the spiral increases up to 1 turn in 40 calibres.

The battering projectile which is studless weighs $182\frac{1}{2}$lbs. The battering charge will probably be 90 lbs. of P powder which may be expected to give a muzzle velocity of about 2,000 feet per second, to be reduced to 1,740 at 1,000 yards range, the energies corresponding with these velocities being respectively about 5,000 and 3,780 foot-tons.

The gun was mounted on an ordinary iron carriage and slide, with plate compressors.

With the experimental gun the highest result obtained was in a round (No. 2,284) when a forged steel shell, hardened in oil, weighing $182\frac{1}{2}$lbs. and having a $1\frac{1}{2}$ diameter head, was fired with an exceptional charge of 111 lbs. of P powder, and very nearly passer through a solid unbacked iron plate, $16\frac{1}{2}$ inches in thickness, which it struck with a velocity of 2,212 feet per second, the striking energy being 6,190 foot tons. The shell remained entire in the plate. As, however, the gun will not fire so large a charge when in the service this performance is valuable only as an experimental result.

With the battering ammunition above mentioned the breech-loading gun will probably be capable of perforating unbacked armour at various ranges as follows :—

| | | | | | | |
|---|---|---|---|---|---|---|
| At the muzzle | it will | perforate | about | $14\frac{3}{4}$ | inches | of iron. |
| ,, 1,000 yards | ,, | ,, | ,, | $12\frac{1}{2}$ | ,, | ,, |
| ,, 2,000 ,, | ,, | ,, | ,, | $10\frac{3}{4}$ | ,, | ,, |
| ,, 3,000 ,, | ,, | ,, | ,, | 9 | ,, | ,, |
| ,, 4,000 ,, | ,, | ,, | ,, | $7\frac{1}{2}$ | ,, | ,, |

Trials, similar to those which I have mentioned as having been made with 6-inch projectiles of different weights but striking with equal energy, were made with the present gun and with somewhat similar results; that is to say, a light shot of $132\frac{1}{2}$lbs. weight did not produce nearly so much effect upon the armour as a medium shot of $182\frac{1}{2}$lbs. did, and there was not much difference between the effects of the medium and the heavy shot of $232\frac{1}{2}$lbs.

In the course of these trials there was a remarkable instance of tenacity combined with hardness in a chilled cast iron shell, of $182\frac{1}{2}$lbs. weight, which struck a 10-inch iron plate with a velocity of 1,337 feet per second, and remained sticking in it entire, and perfect in form, without a crack that could be observed in it. Its point reached 6 inches beyond the back of the plate.

These trials shewed a decided advantage, as regards perforation, in the head struck to a radius equal to double the diameter of the body of the shell over that struck to one diameter and a half.

### New Muzzle-loading 13-pr. Field Gun against Armour.

In order to extend our range of information, on the subject of piercing armour, to guns of small calibre, the 13-pr. field gun, which is now on trial before introduction into the service, was selected for a series of experiments which have given some clear results. The shot used were of solid chilled cast iron of two weights—one set being nearly the weight of the service shot, or about $13\frac{1}{4}$lbs., the other about $10\frac{1}{4}$lbs.

Various charges were used to effect exact perforation of different thicknesses of wrought iron plate, and the following are the general results with the shot of about the service weight and the service charge:—

| | | | | | | |
|---|---|---|---|---|---|---|
| At the muzzle | it will | perforate | about | $4\frac{1}{2}$ | inches | of iron. |
| ,, 1,000 yards | ,, | ,, | ,, | $3\frac{1}{4}$ | ,, | ,, |
| ,, 2,000 ,, | ,, | ,, | ,, | $2\frac{1}{2}$ | ,, | ,, |
| ,, 3,000 ,, | ,, | ,, | ,, | 2 | ,, | ,, |
| ,, 4,000 ,, | ,, | ,, | ,, | $1\frac{3}{4}$ | ,, | ,, |

The lighter set of shot required a little more energy to pierce any given thickness of plate than the set of about the service weight. One of the chilled cast iron shot weighing $10\frac{1}{4}$lbs. struck a $4\frac{1}{2}$-inch iron plate with a velocity of 1,699 feet per second, and remained sticking in it quite uninjured. This is by far the highest velocity at which a projectile has been stopped by armour without breaking up.

It may be mentioned here that some breech-loading 13-pr. field guns on the lines of this gun have been made for trial.

### Comparison of Steel-faced Armour with Simple Wrought Iron Armour.

In the course of some trials, which have extended over the last two years, with the primary object of determining the best form and material for battering projectiles, much valuable experience has been gained in respect of the behaviour of compound (steel and iron) armour-plates in comparison with ordinary rolled iron armour, and although this enquiry has not yet been carried to the full extent contemplated for it, the following summary of results may be useful so far as it goes.

In Paper XVIII., Vol. I. (Part I. of this subject), some account was given of the method of manufacturing steel-faced armour, and I may say here that with one exception nothing new has taken place in the way of making these plates. This exception is that, at Sheffield, some plates have been made by running the steel against the face of the wrought iron plate when standing on the edge; the object being to get rid of air bubbles, and consequent honeycomb defects. The chief point still requiring investigation is that of the exact degree of hardness to be given to the steel. Some good results have been obtained with these plates when the steel contained even 0·6 and 0·8 per cent. of carbon.

In general the steel face is still made to occupy about one-third of the total thickness of the plate, but it is a question whether this proportion should not be less.

The gun used in these trials has been the 9-inch service gun of 12 tons weight, throwing projectiles of 274½lbs. with a charge of 75 lbs. of P2 powder, at velocities, on striking, of a little over 1,500 feet per second.

In an early stage of the trials a number of manufacturers—both English and Continental—entered into competition, with projectiles of chilled cast iron, forged steel, and cast steel, in practice at wrought iron plates, and this resulted in only three being selected as fit for the more advanced stages, of the investigation, namely :—

(*a*) Chilled cast iron shell by the Royal Laboratory Department, of a better manufacture than the service make, a percentage of steel being introduced.

(*b*) Forged steel shell by Sir J. Whitworth & Co., of their fluid compressed steel.

(*c*) Cast steel shell by Messrs. Cammell & Co., Sheffield, of special manufacture, the heads being said to be of chilled white iron.

Against unbacked wrought iron plates *in direct fire*, the chief results obtained were these :—

The very same Whitworth shell was passed several times through 12 inches of armour without any perceptible alteration of its form. Neither the cast steel nor the chilled iron shell completely perforated 12 inches of armour, and there was not much difference between them in regard to work done upon this armour and 14-inch plates, though the cast steel held together much better than the cast iron.

Against unbacked compound (steel and iron) plates, *in direct fire*, a cast steel shell passed through a 10-inch plate (4 inches of steel and 6 inches of iron) which the forged steel shell could not perforate, and against which the chilled cast iron shell had little effect. The cast steel shell, however, broke up. (This shell would, in all probability, have completely perforated a 12-inch iron plate.) The 10-inch compound plate used in this trial measured 7 feet square, and was completely broken up by four rounds.

Against 12-inch compound plates (4 inches of steel and 8 inches of iron) *in direct fire* the cast steel shell had still more effect than the forged steel, but they broke up. The deepest indent in these plates was one of 8 inches. These 12-inch plates were all 4 feet square, and, although cracks were invariably formed in their faces, there was no instance of a plate breaking up by one blow, and the union of the steel and iron was very complete. It was considered useless to fire chilled iron shell against these plates.

Against unbacked wrought iron plates, *in oblique fire*, the greatest effect, at angles from the normal (that is angles between the line of fire and line perpendicular to the face of the armour), varying between $29\frac{1}{2}°$ and $31\frac{1}{2}°$, was produced by a Royal Laboratory improved chilled shell with a head struck to a radius of two diameters of the body. This shell indented the 12-inch plate to a depth of $11\frac{1}{2}$ inches, and knocked a piece off the back of the plate, showing daylight through. The next best result was obtained with the chilled shell with the service pattern head, namely, $1\frac{1}{2}$ diameter. The shells competing on this occasion were of Royal Laboratory improved chilled iron manufacture, with $1\frac{1}{2}$, 2, $2\frac{1}{2}$, and 3 diameter heads; forged steel, with $1\frac{1}{2}$ and 2 diameter heads, and a flat head, the diameter of the flat part being 6 inches; cast steel shell with $1\frac{1}{2}$ and 2 diameter heads, and some with very long conical heads, the tip of one of which was cut off to a flat form.

When the obliquity was increased to 37° with the normal, the Royal Laboratory improved chilled shell, with the 2 diameter head, still maintained its superiority.

At angles from the normal of about 30° and 31° all the chilled shell bit; at similar angles several steel shell with the longer heads only scooped the plates to depths varying from 5 to 6·65 inches. The flat head showed no superiority over the pointed head.

At an angle from the normal of 37° 4′, all the shells formed mere scoops varying between 4·3 and 6·8 inches in depth.

Out of nineteen shell which struck the 12-inch plate obliquely, only two remained entire—namely, a Whithworth steel shell with a pointed head, and one of the same make with a flat head, but they were a good deal deformed. In other respects the cast steel and forged steel shell may be said to have produced nearly equal effects.

When these trials ceased the 12-inch wrought iron plate, which measured 16 feet 9 inches by 8 feet 1 inch, had stood 19 oblique blows from shot which struck with an aggregate energy of about 83,000 foot-tons, giving an average of about 630 foot-tons per square foot of plate, and the plate was still capable of standing at least 10 similar blows more, which would raise the average to about 960 foot-tons per square foot. This is mentioned in order that a comparison may presently be made between the resistance of wrought iron and compound armour to repeated blows.

In the course of these trials it was proved that a chilled iron shell with a 2 diameter head, striking a wrought iron plate 8·7 inches thick, at an angle 29° from the normal, went completely through it, while a similar shell fired at $30\frac{3}{4}°$ at a 12-inch plate indented it $11\frac{1}{2}$ inches. A similar shell striking the 8·7-inch plate at 35° from the normal, very nearly got through it, whereas, the corresponding effect on a 12-inch plate at 37° was only a scoop 6·8 inches deep. At 40° from the normal, the same pattern of shell merely scooped the 8·7-inch plate to a depth of $4\frac{2}{3}$ inches.

It was also shewn in the course of these trials that the effect of oblique fire from rifled guns is the same whether the shot strike on surfaces inclined to the right hand or to the left.

Against unbacked compound (steel and iron) plates in *oblique fire*, the following have been the principal results:—

As in the direct fire at this compound armour, so in the oblique, the chilled cast iron projectiles of the best manufacture have proved themselves to be ineffective—one struck the 10-inch (4-inch steel, 6-inch iron) plate at an angle of 26° from the normal, and merely made an impression on its face 2·1 inches deep, the shell breaking up of course.

A cast steel shell striking the same plate at an angle of 25° with the normal, made a scoop only $3\frac{1}{4}$ inches deep; and a forged steel shell striking it at an angle of 27° made a scoop only $2\frac{1}{2}$ inches deep.

Both of these steel shell, as, indeed, every steel projectile fired obliquely against compound armour, went to pieces, though not, perhaps, into such small pieces as in the case of the chilled shot.

A flat-headed forged steel shell had little or no advantage over the pointed head at an angle of $25\frac{1}{2}°$.

As regards the facility with which the steel-faced armour of good quality turns off projectiles striking it obliquely, it may be mentioned that a forged steel shell with $1\frac{1}{2}$ diameter head, striking at an angle of only 16° from the normal, made a scoop not more than 3 inches deep.

As regards the efficiency of compound armour under repeated blows, a 10-inch (4 steel and 6 iron) plate, measuring 8 feet by 6 feet was completely broken up by six oblique shots striking with an aggregate of 27,000 foot-tons, giving an average of about 560 foot-tons per square foot. Thus it compares unfavourably in this respect with the 12-inch wrought iron plate above mentioned.

Under single blows this 10-inch compound plate gave very good results, the cracks formed in the steel face were very fine, and there was no apparent weakness in the weld between the steel face and wrought iron back.

For a single blow, or perhaps more, a good 10-inch compound plate will offer, according to the results here mentioned, better resistance than a 12-inch wrought iron plate, provided the plate be not overmatched by the gun.

The effect of overpowering blows on this kind of armour will, no doubt, be more fully shewn in some trials which will probably come off next month (June, 1880), when compound plates of 14-inch, 16-inch, and 18-inch thickness will be opposed to our service 38-ton gun.

One or two results on a smaller scale have lately given indications which must not, in the meantime, be altogether disregarded. Thus, a 9-inch compound plate, measuring 8 feet by 6 feet, was broken in two from end to end by a single direct blow from a 9-inch chilled shell, with a wrought iron cap on its head (total weight 278 lbs.) striking with a velocity of 1,366 feet per second, and the halves of this plate were again broken up badly—one under a blow from another similar capped shell, the other under a blow from an uncapped 9-inch shell.

It may be mentioned here, with reference to what I have said on former occasions on the subject of capped shell, that our recent experience does not lead us to expect any practical advantage from these caps, though they are not altogether inoperative in relieving chilled cast iron projectiles from the first effects on striking steel armour in direct fire. At the best the effects lately obtained with them has been but small, and, in oblique hitting, the cap, no doubt, would do more harm than good.

The general result of these trials as regards the projectiles has been that the 2 diameter head has been reported as the best in form for all battering shell; that chilled cast iron, with a mixture of steel, though highly successful against wrought iron armour, fails in the attack of steel; and that steel projectiles must, therefore, be used against compound armour.

So far as the trials have gone, they are thought to be somewhat in favour of the introduction of compound armour. With a few exceptions the plates of this kind, which have been recently made at Sheffield, have been uniform and good in quality, and the steel and iron generally well united.

Before leaving the subject of these recent trials it may be well to mention a method of bolting compound (steel and iron) plates, which has been found very successful. The objects in view were (1) to avoid drilling bolt holes through the steel face of a plate; (2) to contrive a method by which this object would be secured, while the advantages of the spherical nut and cup principle would also be retained.

These conditions have been met by screwing into the wrought iron back of the armour, without wounding the steel, a hollow cylinder about 5 inches in diameter, the inner end of the bore of which is made cup-shaped, and the outer end is coned, the cup and cone being similar in shape to the holes drilled in our ordinary armour plates. The cup forms a seat for a spherical nut, which is thus free to move in it, and the cone affords room for the bolt (when screwed into the nut) to move through a considerable angle without coming in contact with the cylinder.

In the oblique fire trials against the steel-faced target, above reported, the plate (8 feet by 6 feet in size) was held to timber support by six 3-inch bolts on this plan, and although the fastenings were very severely strained, and the bolts were bent into all kinds of shapes, not one of them was broken, and the nuts were still free to move in their cups.

## Guncotton Shells with Delayed Action Fuzes fired at Armour.

In the course of the foregoing accounts it has been mentioned that forged steel shell, hitting square on the face of the target, have been passed through considerable thicknesses of wrought iron at high velocities without alteration of form taking place, or any other material injury being done to them. This performance in itself is not, perhaps, of much importance, but when taken in connection with the possible use of guncotton for bursting charges, and of fuzes capable of delaying their action until aftei the shells have penetrated the armour, some considerable value has been set upon it.

A series of experiments, therefore, was devoted to this particular subject.

In the first place it was ascertained that a bursting charge of any kind of gunpowder, even when wrapt up in several thicknesses of soft cloth in an unfuzed shell of tough steel, explodes too soon after its impact on thick iron armour to add, in any appreciable measure, to its destructive effect. Moreover, it appeared that the small quantity of powder which a battering shell of strong form can hold is insufficient to break up a tough steel shell in an effective manner. Next, it was shewn that a bursting charge of wet guncotton will bear a very heavy shock of impact on iron in an unfuzed shell without igniting, provided only that the shell remains entire.

After several attempts, a fuze containing fuze composition to be ignited on impact, and designed to burn for several seconds before communicating with a detonator of fulminate of mercury and dry guncotton, also contained in it, was made, which acted well under heavy blows, but when this kind of fuze was tried in shells filled with wet guncotton, and fired against plates which they could only just penetrate, the action was so little, if at all, delayed, that the explosion occurred, so far as our observations went, during the passage of the shell through the plate. The wet bursting charge was, however, in every instance *detonated*, and it broke the steel shell into a great number of pieces.

All that can be said as to the safety of using a guncotton shell thus fuzed, is that in the course of the few rounds fired with them in these trials no explosion before impact did occur; and, as regards the importance of proceeding further with this investigation, it must be borne in mind that for an armour-piercing projectile the most that can be expected is that the delayed action should be accomplished effectively in *direct* fire at *wrought iron* armour only, for the results obtained with steel-faced armour, whether hit directly or obliquely, and with wrought iron armour in oblique fire, as already described in this Paper, seem to narrow the question within this limit.

## Armour Plate Trials which have taken place on the Continent during last year, and more recently.

In Part II. of this subject, Vol. I., page 79, will be found some account of the trials of steel and other armour which took place in Italy in 1876. As a sequel to these the following trial of steel plates, 70-c.m. thick, came off at Spezzia in June, 1879.

All the plates were 9 feet long, 4 feet 7 inches wide, and $27\frac{1}{2}$ inches thick. The weight of each was about $20\frac{3}{4}$ tons.

Four of these plates were set up so as to form one target. Instead of being bolted on, they were covered over their faces and edges with 1-inch plating—each plate being thus, as it were, enclosed in a wrought iron box. The backing consisted of about 20 inches of oak in which were stout wrought iron stringers, and the rear supports were of strong wrought iron construction similar to those used in the targets of 1877, at Spezzia.

Each plate was intended to resist two blows from the projectiles of a 100-ton 17·72-inch muzzle-loading Armstrong gun, fired with a charge of 550 lbs. of Fossano powder, but, as will be seen, they proved altogether unequal to this test.

The first plate was struck by a chilled cast iron shell, weighing, I believe, 1,987 lbs. at a velocity of about 1,700 feet per second. The plate was split into five pieces. The shell penetrated the plate to a depth of 14 inches, but none of it seems to have gone through the target. The plate of course was quite unfit for another round.

The next plate was struck by a shell of Whitworth's fluid pressed tempered steel, weighing about 2,100 lbs. at a velocity of rather more than 1,700 feet per second. This projectile passed completely through, and was found close to the back of the target. The plate was shattered and the pieces were driven away laterally. Its own front casing plate was left nearly in place. The projectile was a good deal set up about the head and deformed. The depth of the indent mark on the steel was $21\frac{2}{3}$ inches.

The third plate was struck by a shell, made also of Whitworth's fluid pressed and tempered steel, weighing nearly 2,000 lbs, which struck with a velocity of 1,737 feet per second. The shell did not pass through, but rebounded and fell close to the front of the target. The penetration mark was about 11·8 inches deep. The shell was very much set up and deformed. This plate broke into six pieces, and the whole target was now reduced to such a state of utter wreck that the experiment had to be discontinued.

The result of this trial can scarcely be considered favourable to the adoption of simple steel armour. At any rate it may be safely said that, if steel armour is ever to be used effectively against very heavy guns, neither the proportions of the plates used on this occasion, nor the mode of fastening them, must be adopted.

In the course of the important and exceedingly interesting trials of Krupp guns, which took place last year at Meppen, in the presence of representatives of almost every European power, and also of those of China and Japan, one or two experiments were made with armour, which, though they played a subordinate part in the trials and were not of much value as regards their results, must not be altogether left unnoticed here.

One of these experiments was supposed to test the comparative value, as regards defensive qualities, of wrought and chilled cast iron armour, but as both kinds were made by Herr Krupp, while neither manufacture is his spécialité, and one certainly belongs to a rival maker, the trial could not in any case have afforded a satisfactory comparison. Besides, the 15·5-c.m. breech-loading gun used in the experiment was altogether inadequate for the purpose of testing the relative endurance of two kinds of very thick armour, the wrought iron plate being some 20 inches, and the chilled iron plate being at its thickest part 24·6 inches, thick. The wrought iron plate represented the front of a shield, and its port was covered by a massive stopper presenting a convex rounded surface to the front. The chilled iron mass represented a cupola with very sloping rounded surfaces exposed to fire. The wrought iron plate was, of course, but little damaged by either chilled cast iron, or forged steel shot from this gun, and under this insufficient trial the port stopper turned the shot without being materially crippled. The chilled cast iron target also came off without serious damage, the greatest depth of penetration of a steel shot into the chilled cast iron having been $3\frac{1}{2}$ inches. The surface of the chilled iron flaked off in the neighbourhood of the shot marks, and there was some cracking. To give two such targets anything like a fair trial a much heavier gun than one throwing a 90-lb. shot should have been employed.

The naval armour plate experiment at Meppen was one in which Krupp's long 24-c.m. (9·45-inch) breech-loading gun of $17\frac{3}{4}$ tons weight, firing 348 lbs. steel shot with a striking velocity of upwards of 1,850 feet per second, was used against a so-called Sandwich target. The target was made up of a front wrought iron armour plate, 12 inches thick, separated from a back plate of the same material, 8 inches thick, by a space of 3 inches which was lightly filled with fir wood. The plates were rolled at Dillingen. Two rounds were fired at the target. In the first the shot went clean through both plates and ranged 2,400 yards after doing so. In the other the shot went 1,310 yards after passing through both plates. The front plate was a good deal cracked by the shot and proved to be very brittle. The back plate was much under-welded. Considering that a Sandwich target of proper material and construction, presenting 20 inches of wrought iron in two thicknesses, would be *only just* perforated by one of the shots used in this trial, the facility with which they went through the target on this occasion must be accounted for by its inferiority in some important features, and these I think were its principal points of weakness :—First, the plates were bad. Next, the interval between them was insufficient. Thirdly, I suspect the method of holding the plates was a failure—indeed, I cannot find that they were bolted together at all.

This experiment, therefore, is chiefly interesting and instructive in showing how great a difference there is between a good and a bad target as regards resistance to the penetration of heavy shot.

Lastly, we come to some trials which the French Government concluded at Gâvre, in the spring of the present year (1880). From the little information that I have been able to collect respecting them, it appears that in these experiments there were two cast steel plates made by the Terre Noire Company, one of which was tempered in oil, and the other annealed only. M. Schneider, of Creusot, sent one hard and one soft steel plate, forged and tempered in oil; Messrs. Cammell and Co., of Sheffield, sent a compound plate ($\frac{1}{3}$ steel face, $\frac{2}{3}$ iron); and M. Marrel, of Marseilles, sent an iron plate, its face being formed of a hard iron. All the plates were about 6 feet 6 inches square, and 20 inches thick on the top, tapering to 16 inches on the lower edge, and represented the intended water-line armour of a ship of war. They were backed by oak timber, and bolted to it.

The gun used was the 32-c.m. steel breech-loading gun of the French service, weighing about 40 tons; the charge was 160 lbs. of powder; the projectiles were of chilled cast iron, with soft bodies weighing 760 lbs.; the range was 87 yards; and the velocity about 1,460 feet per second.

Each of the Terre Noire plates broke into 6 or 7 pieces at the first round, and in one case the shot penetrated into the backing. The Marrel plate broke into 3 pieces, and the Creusot plates into 2 and 3 pieces. The Sheffield compound plate broke in two at the first round, but it stood other rounds afterwards, I believe, with better success. On the whole the compound plate may be said to have done better than the others, but the result seems to point to the fact, that even backed compound armour plates are liable to be broken up when overpowered by the shot.

## Increasing Powers of Battering Ordnance.

As my last Paper on the subject of armour plate trials concluded with a few remarks as to the effect which the changes that were then taking place in the powers of rifled guns would be likely to have upon works of coast defence, so I propose now to say something on the same subject.

And to begin with I may state that in this country the principle of breech-loading for guns of all degrees of power is now about to be fairly tried.

The importance of this step is obviously not to be measured merely by the advantage in regard to the facility of serving a given gun, which may attach to either system of breech or muzzle-loading, or to small improvements in shooting qualities. The fact of the matter is that upon this question depends the all important consideration of whether, in our works of coast defence, we can introduce guns of greatly increased power, with slight alteration of the works, or whether we are to remain for ever content with our present armaments, while the powers of offence of other countries are being largely increased. I purposely treat the question here as affecting works of fortification, because it is in that way, of course, that it belongs more strictly to the subject with which I have to deal; but undoubtedly the armaments of fleets are also vitally affected by it, and the importance of the matter in this respect cannot be overrated.

My meaning as regards works of coast defence may be explained by a single illustration. The 38-ton service gun has been pronounced to be the longest and most bulky muzzle-loading gun that could be worked in the casemates of our principal sea forts (indeed there are many, more or less, competent judges who think that we have gone too far in introducing this gun at all into works originally designed for guns of less than half its power and bulk) whereas the same casemates will take, with greater facility, much more powerful guns on the breech-loading principle, such for instance as our projected 43-ton gun, which, at close range, will probably pierce through one third more thickness of iron armour than the service 38-ton muzzle-loading gun, and will, at 3,000 yards range, do as much as the same gun will do at the muzzle.

The facilities attaching to the use of more powerful breech-loading than muzzle-loading guns in confined casemates depend upon the fact that length of gun is of little consideration, because with the former the muzzle need never be brought inside the port in any of the operations of working and loading, whereas every inch of length is of consequence in a muzzle-loading gun, because its muzzle must be brought some distance within the port for loading.

Hitherto the bores of our battering guns have been from 14 to 18 calibres in length, and until recently, foreign guns had very similar proportions; but with the closer research which has been made of late years in this country by Captain Noble, F.R.S., and Professor Able, C.B., F.R.S., into the action of fired gunpowder, together with the attention which has been given to the subject on the Continent, some new light has been thrown upon it, and the means of increasing the power of guns without overstraining them, by the use of much larger charges of slow burning powder in bores of great length, is now more fully understood. Much, however, yet remains to be discovered as to the prorer management of the heavy charges now in use.

Sir W. Armstrong and Herr Krupp were the first to take steps in the new direction, and breech-loading guns are now being made at Woolwich and Elswick, the bores of which are over 26 calibres in length, which, including the chamber, will give such capacity of bore that even the heaviest proposed charge will undergo from four to five expansions during the motion of the projectile in the gun.

Having said this much by way of indicating generally the change which is coming over the question of heavy gunnery, I shall proceed to give some information as to the power of the various battering guns with which we shall probably have to deal in the immediate future, and in doing this I propose to take them in groups, bringing together, as far as possible, guns of about the same weight.

In all cases the perforations given are those of chilled cast iron projectiles with two diameter heads in solid wrought iron armour.

In the first group will be included four guns which stand distinctly by themselves as regards weight, but unfortunately there is with nearly all of them some uncertainty still as to the greatest amount of work which can with safety be got out of them. These guns are:

(*a.*) Our Woolwich 80-ton muzzle-loading guns, of 16-inch calibre, with four of which the turrets of H.M.S. *Inflexible* will be armed. The only other two in course of construction being intended for the turret now approaching completion on Dover Pier.

(*b.*) A 40-c.m. (15·75″) Krupp breech-loading gun of 71 tons.

(*c.*) The eight 100-ton muzzle-loading 17·72 inch guns which were made at Elswick. Four of these were purchased by our Government for use at Gibraltar and Malta; the others forming the armament of the two Italian ships *Duilio* and *Dandalo*. One of these, however, has lately had its breech blown away.

(*d.*) An Italian rifled breech-loading land service gun of 105 tons, made of cast iron with superposed steel rings, having the same calibre as the 100-ton guns (*c*), but throwing a heavier shot.

The French have also a 42-c.m. gun of 72 tons, but I believe it is still in an experimental stage, and little is known of it.

Of this group it may be said that the 100-ton gun (*c*), firing its 2,002-lb. shot, with a muzzle velocity of upwards of 1,700 feet per second is, by a good deal, the most powerful gun at any range. At the muzzle, with an energy of upwards of 41,000 foot-tons, it would probably pierce 28 inches of solid wrought iron armour, and at 3,000 yards 22 inches. But, as it was after firing charges giving the above velocity that the gun burst at Spezzia, I presume these performances must be taken as being beyond its safe strength. If, as seems probable, the charge will have to be reduced so that only 1,550 feet of muzzle velocity be obtained, then it will perforate about 25 inches of solid iron at the muzzle, and about 20 inches at 3,000 yards.

At this rate Krupp's gun (*b*) throwing a 1,708-lb. shot with a muzzle velocity of 1,650 feet (which will probably be a safe performance) will beat the 100-ton gun by 1½ inches of iron at the muzzle, and by the same thickness of iron at 3,000 yards.

Also at the same rate, our 80-ton gun (*a*) throwing a shot of 1,700 lbs., with a velocity at the muzzle of 1,600 feet, which it will probably do with safety, will do rather more than the 100-ton gun at the muzzle, and about the same amount of perforation as it at 3,000 yards, while if the Italian 105-ton gun (*d*) can throw its 2,200-lb. shot with a muzzle velocity of 1,500 feet per second, it will perforate nearly 25½ inches at 3,000 yards, thus coming next in power of perforation to the Krupp gun (*b*) at all ranges.

Next there is a Krupp rifled breech-loading gun, 35·5-c.m. (13·98 ins.) in calibre, and weighing 51 tons, which seems to stand rather by itself. It throws a shot of 1,157 lbs. weight with a velocity of 1,650 feet at the muzzle, and with this it would perforate about 23 inches of iron at the muzzle, and 18 inches at 3,000 yards.

Next may be taken a group composed of the following guns weighing from 35 to 46 tons:

(*e.*) Our 12-inch rifled breech-loading gun of 43 tons, which is now in an advanced state of construction.

(*f.*) A French 34-c.m. (13·38 ins.) rifled breech-loading gun of 46 tons.

(*g.*) An 11-inch gun of Sir W. Armstrong and Co., weighing 35 tons.

(*h.*) A Krupp 30·5-c.m. (12-inch) breech-loading gun of 38 tons.

(*i.*) Our 12½-inch 38-ton rifled muzzle-loading gun.

(*j.*) A French 32-c.m. (12·6-inch) rifled breech-loading gun of 38 tons.

(*k.*) A Russian 12-inch rifled breech-loading gun of 40 tons.

Of these seven guns, our projected 12-inch gun (*e*) will be by far the most powerful. If it should succeed in throwing, as is intended, a 714-lb. shot with a muzzle velocity of 2,000 feet per second, it will perforate nearly 24 inches of iron at the muzzle, and some 18 inches at 3,000 yards, and thus will somewhat exceed, at ranges up to 4,000 yards, the power of the 51-ton gun mentioned above, as standing by itself in regard to weight.

The French gun (*f*) throwing a 927-lb. shot, with a velocity at the muzzle of 1640 feet per second, will perforate nearly 21 inches at the muzzle, and 16 inches at 3,000 yards; and Sir W. Armstrong's gun (*g*) throwing a 535-lb. shot, with a muzzle velocity of 1,875 feet, will perforate about 20½ inches at the muzzle, and 15 inches at 3,000 yards.

The next gun (*h*) in this group, the 30·5-c.m. Krupp gun, throwing a 734-lb. shot, with a muzzle velocity of 1,650 feet, will perforate about 19½ inches of iron at the muzzle, and 15 inches at 3,000 yards.

Our 12½-inch gun (*i*) comes next, throwing an 818-lb. shot with a muzzle velocity of 1,460 feet, and perforating 18 inches of iron at the muzzle, and 13½ inches at 3,000 yards.

Next to this comes the French gun (*j*), throwing a 760-lb. shot with a muzzle velocity of 1,450 feet per second, and perforating about 17 inches of iron at the muzzle, and about 13 inches at 3,000 yards. The Russian gun (*k*) if it throw its 650-lb. shot at no higher velocity than 1,450 feet, which is the most I can trace, will only perforate about 16 inches at the muzzle, and 12 inches at 3,000 yards range.

The United States Government are, I believe, experimenting with a 12¼-inch gun of 40 tons for their land service, and if this should throw a shot of 700 lbs., with a muzzle velocity of 1,480 feet, which is to be expected of it, it will probably perforate about 17 inches of iron at the muzzle, and nearly 13 inches at 3,000 yards, thus placing it on about a level with the French gun (*j*) in the above group.

The Whitworth steel 35-ton muzzle-loading guns of 12 to 11-inch hexagonal bore, which were taken over by our Government in the *Independencia* (now H.M.S. *Neptune*), when she was bought of the Brazilian Goverment, throw steel shell of various weights with velocities giving energies at the muzzle of some 8,800 to 9,500 foot-tons. These would probably have less penetrative effect than similar shell from the French gun (*j*) in the above group, and only a little more than the same from the Russian gun (*k*).

In the next group will be taken seven guns, varying in weight between 22½ and 28 tons, and here will be observed the enormous increase of power, per ton of gun, which will be developed in the new type of long ordnance.

(*l*.) The Woolwich projected 10·4-inch rifled breech-loading gun of 26 tons.

(*m.*) A 10-inch rifled breech-loading Armstrong gun of 25 tons.

(*n.*) A 27-c.m. (10·6-inch) French gun of $27\frac{3}{8}$ tons.

(*o.*) Our service 11-inch muzzle-loading 25-ton gun with the increased charge proposed for it.

(*p.*) A 26-c.m. (10·2-inch) German gun of $22\frac{1}{2}$ tons.

(*q.*) A 28-c.m. (11·02-inch) Italian gun of 25 tons.

(*r.*) An 11-inch Russian gun of 28 tons.

Of the guns in this group, the projected Woolwich gun (*l*) will in all probability be the most powerful at all ranges. Thus, if it succeed in giving to a 462-lb. projectile a muzzle velocity of 2,076 feet per second, it will perforate $21\frac{1}{2}$ inches of iron at the muzzle, and $15\frac{1}{2}$ inches at 3,000 yards, and so be on a par, as regards perforation, with the second best gun (*f*) in the previous group.

Next to this will come the 10-inch gun (*m*), which, with a 400-lb. projectile having a muzzle velocity of 2,000 feet per second, will perforate 20 inches of iron at the muzzle, and 14 inches at 3,000 yards.

The 27-c.m. gun (*n*) with a shot of 476 lbs., and muzzle velocity velocity of 1,640 feet per second, will perforate $16\frac{3}{4}$ nches of iron at the muzzle, and 12 inches at 3,000 yards.

Our service 11-inch gun (*o*), if it can be made to throw a 550-lb. projectile with a muzzle velocity of 1,475, will pierce 16 inches at the muzzle, and 12 inches at 3,000 yards, thus very nearly equalling, if not exceeding, the power of the last named gun (*n*). If a muzzle velocity of only 1,410 should be obtained in the 11-inch gun (*o*), then its perforations will be reduced by about 1 inch.

The 26-c.m. gun (*p*), with a shot of 384 lbs., thrown with a velocity at the muzzle of 1,588 feet per second, will perforate about $14\frac{3}{4}$ inches at the muzzle, and 10 inches at 3,000 yards, thus beating by a little, at short ranges, the 28-c.m. gun (*q*), which, with a projectile of 535 lbs., at a muzzle velocity of 1,312 will perforate $13\frac{3}{4}$ and $10\frac{1}{2}$ inches respectively at the muzzle and 3,000 yards range.

The last gun of this group (*r*), throwing a shot of 484 lbs., with a muzzle velocity of 1,286 feet per second, will perforate about $12\frac{3}{4}$ inches at the muzzle, and $9\frac{3}{4}$ inches at 3,000 yards range.

In the next group will be mentioned eight guns, which are with one exception, about 18 tons in weight, viz.:

(*s.*) Our projected rifle breech-loading gun of 9·2-inch calibre, and 18 tons weight.

(*t.*) Sir W. Armstrong's gun of 9-inch calibre, and 18 tons weight.

(*u.*) Krupp's 24-c.m. (9·45-inch) gun of $17\frac{3}{4}$ tons weight.

(*v.*) A 10-inch gun of 20 tons, supplied by Sir W. Armstrong to the Australian Government.

(*w.*) Our service 10-inch 18-ton gun, firing the increased charge proposed for it.

(*x.*) A German 26-c.m. (10·2-inch) gun, of $18\frac{1}{2}$ tons.

(*y.*) An Italian 25-c.m. (9·8-inch) gun of 18 tons.

(*z.*) An American land service gun of 10-inch calibre, and 18 tons weight.

Of these, if Sir W. Armstrong's gun (*t*) realize what has been set down for it, viz., to give to a projectile of 250 lbs. the enormous velocity of 2,250 feet per second, it will, at short range give the greatest perforation, or about 19 inches of wrought iron at the muzzle; but its energy will fall off so rapidly that at 3,000 yards it will perforate only 12 inches.

Compared with this, our projected gun (*s*) will have slightly less effect at very short range, that is, a perforation of about $18\frac{2}{3}$ inches of iron at the muzzle; but it will maintain its energy better, and so perforate rather more, or about 13 inches at 3,000 yards.

Krupp's gun (*u*) comes close up to the two just mentioned, if it can give, as reported, a muzzle velocity of 1,891 feet per second to a shot of 352 lbs. weight, because this gives a perforation of 18 inches at the muzzle, and $12\frac{1}{2}$ inches at 3,000 yards.

Sir W. Armstrong's Australian gun (*v*), gives a velocity of 1,610 feet at the muzzle to a shot of 400 lbs. weight, which should be equal to a perforation of about 16 inches at the muzzle, and 11 inches at 3,000 yards.

There is somewhat of a gap between these guns and the next best one of this group, viz., our service 18-ton gun (*w*), with the improved charge of 100 lbs. P2 powder proposed for it; for if this charge give a muzzle velocity of 1,510 feet per second to a shot of 411 lbs. it will perforate about $14\frac{3}{4}$ inches of wrought iron at the muzzle, and $10\frac{1}{2}$ inches at 3,000 yards. With its present service charge, this gun will perforate two inches less than these thicknesses.

The next in power is the German gun (*x*), which is reported to give a velocity of 1,542 feet per second at the muzzle to a projectile of 384 lbs. With this it would perforate $14\frac{1}{4}$ inches and 10 inches of wrought iron, at the muzzle, and at 3,000 yards respectively.

The remaining two guns (*y* and *z*), are very nearly on a level. The former with a shot of 392 lbs., and a muzzle velocity of 1,409 feet per second imparted to it, will perforate about $13\frac{1}{2}$ inches of wrought iron at the muzzle, and nearly 10 inches at 3,000 yards, while the latter with a shot of 400 lbs. weight, and a velocity at the muzzle of about 1,389 feet per second, will do about the same.

The advantage of the new type of gun is clearly shewn in this group, by comparing the two guns (*s* and *w*) of the same weight, the bore of the former of which is 25·6 calibres in length, and is chambered, while that of the latter is only about 14½ calibres long.

In the next group only two guns will be mentioned, viz., one which represents the most powerful of the class of muzzle-loading guns of about 12 tons weight, of the type in use in late years; and the other, representing the new type of long breech-loading guns of about the same weight, which has been described in the early part of this Paper as giving excellent results in experimental trials.

The latter will be taken first, viz.:

(*aa.*) Sir W. Armstrong's rifled breech-loading gun of 8-inch calibre, and 11½ tons weight.

(*bb.*) Our service 9-inch rifled muzzle-loading gun of 12 tons, firing the increased charge of powder proposed for it for the future.

The former of these (*aa*), firing a charge of 90 lbs. of pebble powder will give (as stated in the description of this gun's trials against armour) to a shot of 182½ lbs. weight a muzzle velocity of 2,000 feet per second. With this it is capable of perforating about 14¾ inches of wrought iron at the muzzle, and 9 inches at 3,000 yards.

Comparing this with the performance of the old type of gun (*bb*), the charge of which is, I believe, to be increased from 50 lbs of P. to 75 lbs. of P2 powder, we find that this latter, under the most favourable cirumstances, will not give to its projectile of 258 lbs. a greater muzzle velocity than 1,540 feet a second, and with this its perforation will be about 12 inches at the muzzle, and 8 inches at 3,000 yards; in other words, the new and lighter gun will pierce 2¾ inches more armour at the muzzle than the service gun, and will maintain its superiority up to 3,000 or 4,000 yards. Also, the new gun will do at about ¾ mile what the service gun can do only at its muzzle.

It will be seen that the 8-inch gun has a bore 26 calibres in length with a chamber. The service gun has a bore of less than 14 calibres in length without a chamber.

In the last group I shall give three guns of the new type of about 4 and 5 tons weight, and compare them with our service gun of 7 tons weight. These are

(*cc.*) Krupp's 15-c.m. (5·86-inch) rifled breech-loading guns of 3 tons, 18 cwt.

(*dd.*) Sir W. Armstrong's 6-inch rifled breech-loading gun of 4 tons.

(*ee.*) A 16-c.m. (6·28-inch) French gun of 5 tons.

(*ff.*) Our service 7-inch rifled muzzle loading gun of 7 tons.

There are other guns on the Continent that might have appeared in this group, had my information concerning them been more complete.

Beginning with Krupp's gun (*cc*), this I find has a comparatively heavy shot for its calibre, namely, one of 112·4 lbs., and it fires a charge of 33 lbs. of powder; with this the muzzle velocity of the shot is about 1,670 feet per second, and the corresponding perforation of iron would be about 11·4 inches. At 3,000 yards it would perforate about 7·4 inches.

Next to this come the two guns (*dd* and *ee*) which are very nearly equal to each other as to power of perforation, that is to say, the former, Sir William Armstrong's, firing a shot of 80 lbs. with a muzzle velocity of 1,930 feet per second, perforates nearly 11 inches at the muzzle, and $5\frac{3}{4}$ inches at 3,000 yards, whereas the latter firing a shot of 99 lbs., with a velocity of 1,738 feet per second, would perforate about 10·8 inches at the muzzle, and 6·2 at 3,000 yards.

Our service gun (*ff*) firing a shot of 115 lbs., with a muzzle velocity of about 1,525 feet per second, comes last in the group, for at the muzzle it perforates only $9\frac{1}{4}$ inches of wrought iron, and at 3,000 yards about $5\frac{1}{2}$ inches.

Before leaving this subject it is but right that I should say that in the present state of uncertainty and transition in all matters connected with the use of heavy powder charges in guns (the nature of the powder, the best gravimetric density for it, the part in which a heavy charge should be ignited, and many similar points being still under consideration), the powers which I have assigned to the various guns in this Paper must be taken as only the nearest approximations that can be given for the present time, and not as final or likely to hold good altogether for the future.

Besides, in addition to the above elements of uncertainty as to the future power of any given gun in connection with its powder charge, there is another of almost equal importance depending upon the question of the best weight to be given to its battering projectile. The effect of giving more weight to the projectile of a given gun is, of course, tantamount to extending its battering power to greater ranges, for the lighter shot loses its energy through the atmosphere's resistance at a much quicker rate than the heavier, but it is not generally known to what a great extent this apportionment of weight to the projectile affects the power of a gun.

Having had occasion recently to enquire into this matter with regard to the new long 6-inch and 8-inch breech-loading guns referred to in this Paper, a few facts arrived at by calculation may be of some service in explaining the above statement.

Thus, taking first the 6-inch gun, four different weights of shot were assumed, namely, 60, 80, 100 and 120 lbs., and giving these all equal energy of 2,067 foot-tons at the muzzle, it was found that their ranges of equal energy would be about 500, 700, 800 and 1,000 yards, or 1,000, 1,300, 1,600 and nearly 2,000 yards, or 1,500, 2,000, 2,500 and 3,200 yards; that is to say the heaviest shot would have theoretically equal penetrative power with the lightest at about double its range.

With the 8-inch gun the results were equally striking. For this four shots were taken of 132, 182, 232 and 282 lbs. weight respectively, and, leaving the muzzle with the same energy of 4,920 foot-tons, their ranges of equal energy and, therefore, of equal theoretical penetration, would be 500, 750, 900 and 1,100 yards in one case, 1,000, 1,400, 1,750, and 2,100 yards in another case, and 1,500, 2,100, 2,600 and 3,200 yards in another.

It must be understood that it cannot be argued from this that weight can be added to battering shot *ad libitum*. Practical questions of gunnery will soon put a limit to the weight of the projectile, and even if they did not interfere, the consideration of the most effective form of shot for penetrating armour would assign an early limit to it. But, nevertheless, taking this matter in conjunction with the results in the trials of shot of different weights, but with equal *vis viva*, against armour, as mentioned in the course of this Paper, enough has been shown to mark the importance of ascertaining, for each gun, what is the best weight of projectile for battering purposes, and to discredit the notion which seems to be gaining ground, that the value of a battering gun is to be measured by the highest velocity which it can give to any projectile.

*May*, 1880. T.I.

*P.S.*—In speaking of compound (steel and iron) plates in the foregoing Paper, I said it was likely that some trials of thick armour of this description would probably take place before long. These have now gone so far that I can give a short account of the experiments, and of the conclusions to be drawn from them.

The plates were in every case backed by massive oak, against which they were strongly held, without being actually bolted to it. The gun used was the service $12\frac{1}{2}$-inch 38-ton gun, at a range of a little under 100 yards, which is just sufficient for taking velocities. The fire was *direct*.

The first plate was $14\frac{1}{4}$ inches thick, composed of a face of $4\frac{1}{4}$ inches of steel (containing 0·8 per cent. of carbon) on a back of 10 inches of rolled iron. It measured 7 feet high and 7 feet 7 inches wide, and weighed 13 tons 1 cwt. It was slightly curved and presented its convex surface to the gun. The shell was of tempered cast steel, weighing 826 lbs. 4 oz., and had a $1\frac{1}{2}$ diameter head. It was fired with a charge of 160 lbs. of P2 powder, and struck the centre of the plate with a velocity of 1,435 feet per second, which gave an energy on impact of a little over 11,800 foot-tons. It completely broke up the plate into three large pieces, and got about 12 inches into the wood backing. The shell was broken up.

The next plate was of the same superficial dimensions, but it was 16 inches thick, made of 5 inches of steel and 11 inches of iron. The plate weighed 14 tons 4 cwt. and was curved. The shell, of the same make as the last, was fired with 180 lbs. of P2 powder, and struck the centre of the plate with a velocity of 1,473 feet per second, and an energy of 12,460 foot-tons. The plate was completely broken in two by it, and extensively cracked besides, but the indent formed by the shell was not more than $10\frac{1}{2}$ inches deep. The shell was broken up.

The third plate, which was the manufacturer's own property, was in all respects the same as the second, except that the steel in it was harder, containing 0·8 per cent. of carbon as against 0·5 per cent. in the other. This plate was broken into four or five pieces; the indent made by the shell was about 10·9 inches deep. The shell was broken much as before.

The fourth plate, which was also the manufacturer's own plate, was 18 inches thick, and was made up of about 5 inches of steel and 13 inches of iron. It was not curved. It measured 9 feet 6 inches by 7 feet 7 inches and weighed upwards of 23 tons. The steel contained about 0·5 per cent. of carbon. Unfortunately it was decided, on the manufacturer's recommendation, that the first round at this plate should be fired with a service chilled cast iron shell, which material all recent experience has shown to be quite ineffective against steel armour. The shell weighed 800 lbs., and being fired with 180 lbs. of P2 powder, it struck with a velocity of 1,500 feet per second, and an energy of about

12,500 foot-tons. The shell did exactly what was expected of it by those who had watched previous trials, that is—the head of the shell remained sticking in the front of the plate in the form of a "splash," having penetrated only about one-third of the entire thickness of the plate, and cracked the steel face in all directions; one of these cracks went through the iron back of the plate; the back of the armour showed only a slight bulge. It is not yet decided whether this plate is to be further tested with a steel projectile or not.

The conclusions to be drawn from the present trials are these:—First, that the best compound yet made will go to pieces under the blow of a shot which is capable of penetrating it to a depth of three-quarters of its entire thickness, and that the face will be extensively cracked by any shot that can penetrate even a short distance into the steel. Also, that for a single blow a good compound plate will stop a shot which would perforate an ordinary iron armour plate of from one eighth to one fourth greater thickness.

Compound plates certainly have the further advantage of requiring the use of costly steel shell to attack them, but their tendency to break up under overpowering blows, and to crack extensively under others, greatly reduces the value of thesep lates as at present manufactured.

*July*, 1880. T. I.

# PAPER XIII.

## REMARKS

ON THE

# MILITARY INSTITUTIONS OF SWITZERLAND

AND

## OBSERVATIONS ON THE DIFFERENT ARMS.

By Colonel G. Graham, C.B., V.C., R.E.

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It would be interesting to know what proportion of the 200,000 who are stated to visit Switzerland in an ordinary season, go there for any more serious purpose than to enjoy the magnificent scenery and glorious atmosphere of its lakes and mountains: yet Switzerland deserves more serious study than can be got from the guide books, and its people should not be considered as fairly represented by the host of guides, waiters, beggars, and others with whom the ordinary tourist comes most frequently in contact.

During the autumn of 1879 I had the good fortune to be present at the Swiss Army Manœuvres, and without giving any details of the special operations I witnessed, I propose to make a few observations on the military organization of Switzerland and on the different arms.

"The country now known as Switzerland is unique in position, history and institutions. It is the most central position in Europe, as far from the mouth of the Tagus as from that of the Danube; from the straits of Gibraltar as from those of the Dardanelles; from Cape Matapan, south of the Morea, as from Cape Wrath, north of Scotland."—*(Guinaud, Geographie de la Suisse)*.

Switzerland is thus the very heart of the Continent, and from its snow-clad heights pour down the streams that water the plains of central Europe, flowing towards the German Ocean, the Adriatic, the Mediterranean and the Black Sea. Its greatest length, from

Vattuy in the Canton of Vaud, to Martinsbrücke in the Grisons, is about 208 miles, and its greatest breadth, from Chiasso in the Canton Ticino, to the northern extremity of Schaffhausen, is 156 miles.

Surrounded by warlike nations, now consolidated into four great powers, it is astonishing how this small tract of country with its heterogenous population should have escaped partition among its powerful neighbours. Nature has only done in part for Switzerland what she has done so thoroughly for us: she has partly isolated her by great mountain ranges, lakes, and rivers. Her boundaries are marked by the Alps on the east and south, by the Jura chain on the north-west, by the Rhine and Lake Constance on the north and north-east, and by the lake of Geneva on the south-east. Thus protected to some extent by these natural barriers, Swiss valour and industry have made and maintained Switzerland a free and flourishing state.

This prosperous condition has not been without interruption, as when in 1799 the French took possession of the Grisons, and Switzerland became the theatre of war between Massena and Suwarow. Switzerland has not yet forgotten the misery of that campaign, when 50,000 foreign soldiers were buried in her soil, and at least 10,000 Swiss were sacrificed in defending isolated posts. The French are said to have burnt, in six cantons alone, nearly 3,000 houses, and to have carried off the treasure of the principal towns. Switzerland was afterwards neutralized, but her neutrality was not respected in the campaign of 1813, and was therefore again formally guaranteed by the Treaty of Vienna in 1815.

The Swiss, however, after such severe lessons dared not trust to any treaty for the maintenance of their neutrality and independence. An army was necessary.

"In 1815 they had scarcely any army; in 1817 they had 18,000; in 1820, 70,000, and now they can put 200,000 men under arms." (*La Neutralité Suisse*, a pamphlet by an officer of the *État Major.*)

But this force, though respectable, is nothing compared with the monstrous armaments of their neighbours, and the Swiss troops though admirable in their way, could not, probably, fight on equal terms with the highly trained armies of the great powers. The condition of their frontiers may also well cause anxiety among the patriotic Swiss, now that the introduction of railways and good communications have done so much to weaken the strength of the natural barriers. By the annexation of Savoy in 1860, France gained access to the southern shores of the Lake of Geneva, and although the neutrality of Savoy was guaranteed in 1815, this guarantee has not been fully acknowledged since the transfer. On the south the Canton of Ticino projects like a wedge into Lombardy, stretching nearly as far as the town of Como, and embracing a considerable portion of the shores of Lago Maggiore and the greater part of Lake Lugano. The construction of the St. Gothard tunnel will, however, facilitate the defence of this outlying Canton, and no forts threaten the Swiss on this side; nor can any apprehensions be felt as regards the Austrian frontier, although the construction of the line to Arlberg would somewhat disturb the equilibrium at this part.

The annexation of Alsace has extended the German frontier by about 25 miles, and would allow of the German forces entering Switzerland without having to cross the Rhine. France touches Switzerland on her west and south-west frontiers for a distance of about 150 miles, and here it is that the Swiss feel most anxiety on account of the new roads, railways, and forts constructed, or in course of construction. "Before 1870 four French forts menaced our west frontier, now five new forts are being built and many more are projected."—*(La Neutralité Suisse.)* By the construction of these forts it is said that Swiss territory will be under perpetual menace of fire from French guns.

The author of the pamphlet already quoted sums up by expressing an opinion which I have heard before from Swiss officers, viz., that the French and Germans have made their respective frontiers so strong that Switzerland (so long as she is unprovided with barrier forts on her exposed frontiers) is the natural battlefield in the next Franco-German war." The French, well protected on the Belfort-Metz side, would find greater difficulty in penetrating the enemy's front than in turning it by way of Switzerland. On the other hand, the Germans would endeavour to forestall them, &c." *(La Neutralité Suisse.)** By the expenditure of about half-a-million sterling, this writer considers their frontier might be made much safer on this side. This involves the erection of barrier forts to cover the railroads, and of some other works in support which he enumerates. The whole question is, however, to be reported on by a Federal Commission under Colonel Dumur, the able chief of the Swiss Engineers, to whose kindness I am indebted for much information.

Like other peace-loving, thrifty communities, the Swiss require to be frightened into any extraordinary expenditure on their defences.

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* The same subject has been very ably treated in a pamphlet that has been noticed in the *Royal Engineer Journal* for March, 1880.

After the campaign of 1866 the Chambers voted $12\frac{1}{2}$ millions of francs (half a million sterling) to arm the infantry with the Vetterli magazine rifle, and after that of 1870 the Swiss Army was reorganised on a federal basis.

Before the law of 1874, each canton had to contribute 30 men per 1,000 to the élite, and 15 per 1,000 to the reserve. The troops of each Canton were kept separate, and the strength of the battalions and companies were very various. Owing to the rivalry and jealousy of the different Cantonal governments, great difficulties stood in the way not only of organising the army, but of keeping it together when called out.

That this army, notwithstanding its defective organisation, would have proved formidable to an invader, is proved by the conduct of that portion called out to protect the frontier in 1870, and to whom Bourbaki's routed forces surrendered in January, 1871. The following abstract from Hepworth Dixon's *Switzers* may not be uninteresting:—

"July 15th, 1870, Friday evening.—On information being received that war was declared, President Dubs summoned his council in hot haste. In one hour the Federal Council agreed to call upon the Cantons to mobilize. Then they agreed to call out five divisions of the élite, the 1st, 2nd, 6th, 7th and 9th. The 1st under Colonel Egtoff to secure the bridge of Bale; the 2nd under Colonel Salis to move on Biel and hold the roads from Solothurn and Delêmont; the 6th under Städler to rest on Berne in reserve; the 7th under Isler to march on Frauenfeld and watch the Rhine against Burg, and the 9th under Schädler to cross the St. Gothard from Ticino, drop down to Altdorf and occupy Lucerne.

"Saturday, 16th.—By noon strong squads of men were falling in before the new town hall in Aarau, the district troops came pouring in . . . early in the afternoon the first Swiss troops were on the road. At midnight the Aarau troops marched into Bale. By Sunday night the 1st and 2nd divisions were complete, and by Tuesday the 6th, 7th, and 9th.

"The strength of these five divisions was as follows:—

| | | |
|---|---|---|
| Staff and guides ... | 104 men ... | 105 horses. |
| 1st division ... ... | 8,296 " ... | 692 " |
| 2nd " ... ... | 8,319 " ... | 632 " |
| 6th " ... ... | 7,377 " ... | 767 " |
| 7th " ... ... | 7,368 " ... | 670 " |
| 9th " ... ... | 5,959 " ... | 671 " |
| Total... | 37,423 men ... | 3,537 horses, |

together with 11 batteries of artillery, counting 65 field pieces.

"These troops were pushed forward to watch the frontiers. A force of Engineers dropped down the Rhine from Burg to Bale, studying every pass and point, and leaving companies of sappers at each bridge, with orders and materials to destroy it should an enemy appear in any strength. A staff of Engineers went over to Bruderholz and drew up plans for fortifying that important point. All railway companies were ordered to report their stock of carriages, &c., and five new telegraph stations were established."

The tide of war however rolled away—past the Swiss frontier to the heart of France.

In January, 1871, the Swiss frontier was again threatened. This time it was not an invasion by an aggressive army that threatened the Swiss neutrality, but a headlong retreat of an army disorganised and demoralized by defeat. Prompt means had to be taken, and four divisions, with two mountain batteries under General Herzog, took the field. They numbered less than 20,000 men. By long quick marches, such as German troops alone could match, the Swiss brigades were thrown along the range from Bassecourt to the Lagne. Manteufel fell on Bourbaki's routed army near Besançon, broke them at first shock and forced them back into Pontarlier, whence he had one issue only, by the gorge of the Fort de Goux, which led them straight upon the Swiss frontiers. The railway line from Berne to Paris passes by the Val de Travers to Pontarlier, and this railway line being open it was evident to General Herzog that the French would try to enter by this shorter path. "It was only by the exercise of great promptitude, decision, firmness, and tact, that General Herzog accomplished his difficult task without bloodshed. The French troops were utterly disorganised and would not listen to their officers, whom they reviled as the cause of their disasters. Herzog accordingly placed the four French armies under charge of his own officers, disarming every man as he crossed the frontier. He issued orders for the French to move on different villages already held by Swiss troops. They were accordingly marched off in bodies of 1,000 each, irrespective of corps, as fast as they arrived, having first laid down their arms. A dozen Swiss soldiers with their pieces charged and bayonets fixed sufficed to lead French columns of 1,000 each."

The Swiss Engineers received the highest praise from General Herzog.

An army that could carry out such a duty as this, could turn out so promptly and show such resolution and discipline in face of such difficulties, must not be looked upon as a mere militia, and it is perhaps worth our while to examine and investigate a little the organisation and conditions that can produce such an army at so small a cost.

The Swiss army is the cheapest in Europe. According to the *Feuille Federale Suisse* for the year 1877, the cost of the army was only 4·94 francs, or 3s. 11d. per head of the population, that of France being 17·62 francs. To estimate this difference, it should be noted that France, with a population of nearly 37 millions, can turn out an army of $1\frac{3}{4}$ millions, or about one man to every 21 of her population, while Switzerland, with a population of only $2\frac{3}{4}$ millions, can turn out 200,000 men, or one man to every 14 of her population. The ratio of expenditure on results in the two countries is therefore as $14 \times 4{\cdot}94 : 21 \times 17{\cdot}62$, or $1 : 5{\cdot}3$. In other words, a French soldier costs five times as much as a Swiss soldier. The conditions of service in the two countries are, however, entirely different. By the articles of the Federal constitution every Swiss citizen, unless specially exempted, is bound to military service between the ages of 20 and 44, 12 years of which are to be in the élite and 12 in the landwehr. Provision is also made by law for the instruction of all boys from the age of 10 upwards in a suitable course of gymnastics, as a preparation for military service. This instruction is to be supplemented by a course of target practice during the last two years (18-20) before entering the service. The course for the infantry recruit lasts 43 days, and repetition courses (cours de répétition) of 16 days are held biennially (see Appendix A).

Military traditions are strong in Switzerland, and the military spirit is jealously fostered among the population. Each citizen is taught to feel himself a soldier, and although not allowed to appear in uniform when not called out, he has to keep his arms and equipment always ready for service and for inspection. The Swiss seem to have a great reverence for old traditions of battles fought long ago. On the walls of the training school at Thun I found a number of pithy speeches inscribed, dating as far back as the battles of Morgarten, Laupen and Sempach, fought more than 500 years ago. In our service such records on a barrack of what was said at Poitiers or Agincourt would be thought at least out of place. To take a more modern instance, it would not probably be thought desirable to have any such stirring remarks as "Up guards and at them!" perpetuated on the walls of the Wellington barracks. Yet in Switzerland this would be strictly appropriate, and similar inscriptions recalling the memory of the battles fought for their freedom appear far from ridiculous to the patriotic Swiss. This traditional reverence for military honour may have had much to do with the loyal efficiency of Swiss legions in foreign service, and it does not need Thorwaldsen's noble monument at Lucerne to remind us that the Swiss in times past may have sold their swords but never their honour.

The country is divided into eight military districts, each of which furnishes 1 division of the élite and 1 of the landwehr. The strength of a division is about 12,800 all told (see Appendix B). By the law of 1874, only the first eight classes of the élite are called out for exercise biennially, *i.e.*, from the age of 20 to 28. In the course of 8 years the troops of each of the 8 divisions of the élite are exercised successively as battalions, regiments, brigades, and divisions. The strength of the several units at their biennial training is therefore considerably below the normal strength. Thus, although the normal strength of a battalion is 774, the battalions of the Canton of the Vaud were remarked to be below 550 at their training. Many of the absentees escape on pretence of health, or occupation, others are exempted by the law. This appears to be a weak point in the Swiss organisation, as it must result in having a number of ill-trained men in every regiment who will impair the general efficiency when the whole body is called out for service.

The whole of the first line of the Swiss army, the élite, numbering over 100,000 men, is now armed with the Vetterli rifle, an adaptation of the Winchester repeater. It will hold 11 cartridges in the magazine and one in the barrel. The repeating arrangement being only adapted for the exact length of the ball cartridge, it cannot be used with the blank, although attempts have been made to supply the place of the bullet with papier-maché. The result of this is that the troops can have no training in fire discipline with the magazine rifle. The arms are kept by the men when off duty, and inspected by the Federal controller of the divisional circle, who, in case of any wilful injury to the arms, can obtain the infliction of summary punishment on the offender through the civil power. The men usually keep their own equipment also, but sometimes (as at Fribourg) it is kept in the Cantonal stores. In this case the commanding officers of battalions have to inspect their men's equipment once a year.

### Cavalry.

The cavalry service is a popular one, and generally sought for by the sons of gentlemen, or of well-to-do farmers. The recruit is furnished with arms, clothing, and equipment, exclusive of necessaries, which he provides for himself. The Federal Government have recently established depôts for remounts and training schools under an Inspector of Cavalry. Most of the government cavalry horses come from Hanover, and all are broken in these training schools. A cavalry recruit may send his own horse to the school, and if approved, it is accepted as a troop-horse, when half its estimated value is paid to the owner, who is bound to retain it for service. The other horses are at the termination of their training, issued to the men who are bound to take them over and to pay the government one-half their value. These horses then remain in possession of the men, who are responsible that they are kept in proper condition. In ordinary course the soldier gets his money returned by yearly instalments one-tenth at a time, as his term of service lasts 10 years. When he has completed his term of service with the same horse it becomes his own property. The horses I saw were of a good, useful stamp, and the men rode fairly well. The Swiss cavalry of the 1st line consists of 24 squadrons of dragoons of 124 men. There are also 12 companies of guides who furnish staff orderlies, messengers, &c. These latter are directly under the Federal Government. The cavalry train annually for ten days during their ten years service in the élite.

### Artillery.

The following is a statemnet of the number of batteries in the Swiss service.

| | In élite. | landwehr. |
|---|---|---|
| Field batteries, 12 of 10 c.m., 36 of 8 c.m., total | 48 ... | 8 { men only. no guns. |
| Mountain batteries 2 (of Krupp's steel guns) | 2 ... | 0 |
| Companies of position (of 122 officers & men) | 10 ... | 15 |
| Columns of the park (of 160 officers and men) | 16 ... | 8 |
| Companies of artificers (of 160 officers & men) | 2 ... | 2 |
| Battalions of the train (of 305 officers & men) | 8 ... | 8 |

The field batteries have 160 officers and men, 20 riding horses, 92 draught and 8 spare horses, and 18 carriages, viz :—6 gun, 6 limbers, 2 spare wheel carts, 1 tool cart, 1 forage cart, 2 provision wagons. The course of instruction for the artillery recruit lasts 55 days.

The artillery are exercised biennially, the field batteries in rotation as batteries, regiments, brigades, and divisions. Thun, which I visited, is one of the principal training schools for artillery. There are barracks there for 1,000 men, stabling for 400 horses, and a large level plain, the *Allmend*, of about 740 acres (300 hectares) for exercising. From March to November every year, 4 batteries are always in training at Thun, 18 days at a time. The training establishment of horses is 19 riding and 65 draught horses. The strength of the batteries for instructional purposes is 120 officers and men. The appearance of the field batteries at the manœuvres and their working was surprisingly good considering their short period of instruction. The service is, I am told, a very popular one, and recruits are carefully selected. The horses were obtained by requisition and broken well together. The Swiss guns are all breech loaders. The breech openings are closed by single wedges, on a very simple principle known as Broadwell's system. For bored up 12 c.m. guns, they have Kreiner's double wedges.

When at Thun I saw one heavy steel 15 c.m. gun made by Krupp, weighing three tons; also a light steel mountain gun of the same maker. A full description of the former, and of experiments is given in the supplement to No. 17 of the *Revue Militaire Suisse*, 1879.

### Companies of Artificers.

In order to meet the demand for the new service ammunition for artillery and infantry in time of war, two companies of artificers were formed. These companies, 160 strong, do their course of instruction as recruits for six weeks at Thun, where they learn how to make up cartridges for artillery and infantry. Every two years they have a course of repetition lasting 18 days, when they make use of the machinery of the reserve. These consist of two companies of the élite, and two of the landwehr, their normal strength being as follows:—

1 captain.
1 lieutenant.
1 serjeant-major.
1 quarter-master serjeant.
10 serjeants.
1 hospital attendant.
2 trumpeters.
143 artificers.

160 Total.

At Thun there is an arsenal capable, I was informed, of turning out annually—11,000 shell, 4,500 shrapnell, and 500 grape. At the time I visited it 200 workmen, including boys, were employed in making up cartridges for the infantry magazine rifle. They make 30,000 cartridges a day at present, but could do more if required. I was told that with machinery and workmen at full power, they can turn out 100,000 cartridges a day, and that the cost is about

60 francs a 1,000, or ·576 of a penny per cartridge. In time of war, the companies of artificers attached to the artillery would assist in the production of cartridges for guns and small arms. The weight of the cartridge is 20 grammes (about $\frac{3}{4}$ oz.). The metal is copper, with 5 per cent. of zinc, but that used for the cavalry revolver cartridge has 30 per cent. of zinc, closely resembling brass.

The construction of batteries forms a portion of the duties of the artillery in the Swiss service. *Fig.* 1, *Plate* I., taken from the artillery handbook, shows a plan and sections of a barbette battery for six guns, with intermediate trenches (*bb*) for the gun detachments, shell recesses (*cc*), and bonnettes (*aa*). The bonnettes have a command of about 2 feet (·6m.) over the crest of the parapet, which is 3 feet (·9m.) above the level of the gun platforms.

*Fig.* 2 represents a sunken gun battery for guns on high carriages firing through shallow embrasures, the sole of which at the genouillère is 7 feet, 2 feet 6 inches (2·20 m.) above the platform. This is the same firing height as given in the German batteries for guns of 15 c.m. calibre, and upwards.

The deep cut embrasure, although still given in the manuals, is in future only to be used in exceptional cases. Shallow embrasures such as those in *Fig.* 2, or as shown on a larger scale in *Fig.* 3, are now preferred.

*Plate* II. shows the various tools used in the construction of the batteries and revetments. The bulk of these is carried in the wagons in charge of the engineers and pioneers, as seen in the following table :—

| Carriages. | Round shovels. *Fig.* 11. | Square shovels. *Fig.* 10. | Pickaxes. *Fig.* 12. | Spades. *Fig.* 14. | Rock picks. *Fig.* 13. |
|---|---|---|---|---|---|
| Sappers' tool carts, 2 with each battalion of Engineers ... ... ... ... | 50 | 4 | 20 | 2 | 4 |
| Pontoon wagons do. do. ... | 24 | 12 | 24 | — | 10 |
| Pioneers' tool carts with divisional parks ... ... ... ... ... ... ... | 50 | 25 | 50 | — | 5 |
| Battery wagons ... ... ... ... ... | 2 | 2 | 2 | — | — |
| Ammunition wagons, either artillery, infantry, or cavalry ... ... ... | 1 | 1 | 1 or 2 | — | — |

In easy soil, two shovellers are placed for one man with a pickaxe, and each shoveller is supposed to shovel ·9 of a cubic metre to a distance of 4 metres in one hour (·9 cub. metre = 31·78 cub. ft.).

The work would be executed as follows:—an officer of artillery would get an order to construct a battery for a certain number of pieces to be ready by a certain hour. He would be directed to make requisition on the park for tools and materials. So many companies of infantry, besides the men of his battery, and a section of sappers, if required, would be put under his orders, and the work would then be carried out under the artillery officer's directions.

## Infantry.

The infantry I saw at the manœuvres were mostly small men, but very active and capable of enduring a great deal of fatigue. The weather was very hot, yet they did not appear to suffer, although carrying full kits with great coats, and frequently doubling over rough ground, and charging up hill. The tactical unit for the infantry is the battalion of 774 officers and men divided into four companies of 185 each.

The battalion staff is made up as follows:—

1 commandant, (major).
1 battalion adjutant, 1 quarter-master, 2 surgeons.
1 ensign, *(Porte drapean)* who is a non-commissioned officer.
1 non-commïssioned officer for the arms.
1 non-commissioned officer of pioneers.
1 non-commissioned officer and 6 soldiers of the train of the line.
1 corporal trumpeter.
1 non-commissioned officer and 2 men, hospital attendants (*infirmiers*).
1 non-commissioned officer and 12 men, (stretcher men.)
2 armourers.
Total, 34 officers and men ; 7 horses.

4 companies each of 185, viz.:
1 captain, 2 1st-lieutenants, 2 lieutenants.
1 sergeant-major, 1 quarter-master sergeant, 8 sergeants.
16 corporals, 4 pioneers, 3 trumpeters.
2 drummers, 1 hospital attendant.
144 soldiers.

(N.B.—The carbineers corps have a 4th trumpeter in place of the drummer, and the instrument played is a sort of *cornet-à-piston*).

Total strength of the battalion:

25 officers.
749 non-commissioned officers and men.
7 horses (chargers).
18 ,, (draught).

6 Carriages, { 2 demi-caissons for reserve ammunition.<br>1 covered cart, baggage, officers'.<br>1 baggage wagon.<br>2 provision wagons.

(See Appendix B.)

Each division has one battalion of carbineers 770 strong. The carbineers are the sharpshooters of the army, and train to a higher standard. They are men selected from among the mountaineers, chamois-hunters, game-keepers, and sportsmen of the country. Their rifle contains only ten catridges in the magazine, and has a hair trigger arrangement, *à double detente.*

All the officers and non-commissioned officers of the infantry have to pass through a course of 4 weeks musketry instruction at the School of Musketry at Fribourg. The weight of the Vetterli rifle is 11 lbs., and the cartridge weighs about $\frac{3}{4}$ oz.

As regards drill, the infantry appear well in hand, and the movements were generally executed with fair precision. Some leaders of subdivisions were seen to halt their skirmishers, or supports, on slopes exposed to enemy's fire, in order to be in line with an adjacent subdivision, when cover might have been found by moving a little further on or further back. Some battalion commanders seemed to prefer close order, and kept their men in double column when under fire. Such errors as these and others would correct themselves on actual service. The Swiss infantry having a magazine rifle, great stress is laid on the importance of the supply of reserve ammunition. Every battalion is accompanied by two ammunition wagons, called demi-caissons, each of which carries 12,000 cartridges, and these wagons are brigaded together under an officer of the train, the brigade being the tactical unit of the Swiss infantry. Each man carries 40 rounds in his pouch, 60 in his knapsack, and the demi-caissons carry 35 more. Total, 135 per man ; 2 demi-caissons per battalion with the divisional park carry another 35, and 30 more are in reserve, making up 200 rounds per man.

In action, the brigade ammunition is kept near the reserves, about 600 to 700 yards from the fighting line, and the officer in charge sends off a demi-caisson, or more, on requisition from any commanding officer. The latter sends 4 men per demi-caisson to meet it, each of whom carries off a sackfull of cartridges which he assists in distributing along the fighting line. The empty demi-caissons are then sent back to the divisional park column and refilled.

The men are practiced in forming shelter trenches, and for this purpose the Linneman spade is used. Eight of these short spades are carried per section, or 32 per company. They are said to be approved as spades for easy soil, and found useful as choppers. During the manœuvres I saw them used for shelter trenches, when each man would dig a length of 4 feet in a quarter of an hour.

### Federal Troops.

The law of 1874 centralized the administration of the army and reorganised those corps which are under the Federal Government, as distinguished from the cavalry, artillery, and infantry which are under their respective Cantonal government.

The Federal Corps* are as follows :—

Engineers, consisting of pontoon companies, sappers, and engineer pioneers.
Infantry pioneers.
Administrative corps.
Sanitary corps.
Battalions of the train.
Divisional parks.

### Engineers.

The old organisation of this branch of the Federal army was as follows :—

| | | | | | |
|---|---|---|---|---|---|
| 3 | pontoon companies and | 6 | sapper companies of | élite. |
| 3 | ,, ,, | 6 | ,, ,, | reserve. |
| 2 | ,, ,, | 6 | ,, ,, | landwehr. |

There was also a Genevese company of sappers which belonged to the landwehr.

Six companies of sappers of the élite and 3 of the reserve were attached to the 9th division of the army.

The remaining companies of sappers, and all the pontooners, formed an engineer reserve under the command of the Chief Engineer, and of the Commander-in-Chief. The pontoon train was not provided with horses, and had to be horsed by requisition. In a general mobilization, the result would probably have been that no horses would have been available for the pontoon train. Three of the divisions of the army had only sappers of the reserve, and in any case a single company of technical troops, numbering 100-125 men, was not enough for a division. The pontoon train was also quite inadequate.

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* Exclusive of 12 companies of guides, which are also Federal troops, already referred to under "Cavalry."

By the present organisation, each division has a battalion of engineers, and 8 corresponding battalions for the landwehr are in process of formation.

A battalion of engineers is 393 strong—

| | | |
|---|---|---|
| There is 1 company of sappers ... | 153 | officers and men. |
| ,, 1 pontoon company ...... | 123 | ,, |
| ,, 1 company of pioneers ... | 108 | ,, |
| ,, battalion staff ........... | 9 | |
| Total ................. | 393 | ,, |

Each battalion has, when mobilized, 133 horses, including 19 saddle horses, and 30 wagons, of which the following is a detail :—

| | Horses. | Draught horses. |
|---|---|---|
| 2 demi-caissons for ammunition with... | 2 | 4 |
| 1 fourgon .................................. | 3 | 3 |
| 1 baggage cart ............................ | 2 | 2 |
| 3 provision carts .......................... | 2 | 6 |
| 1 field forge ............................... | 4 | 4 |
| 2 sappers' tool wagons ................. | 4 | 8 |
| 2 pontoon wagons ....................... | 4 | 8 |
| 12 bridge equipment wagons ........... | 4 | 48 |
| 3 telegraph wagons ...................... | 4 | 12 |
| 1 station ,, ....................... | 4 | 4 |
| 2 railway tool carts ...................... | 4 | 8 |
| Spare teams ............................ | | 7 |
| Total 30 wagons, &c. | | 114 |

## Pontoon Companies.

The men for these companies are carefully selected from a population accustomed to work in the water, as boatmen, raftsmen, &c., and from workmen such as carpenters, boat builders, riggers, &c.

In Appendix D I have given extracts from the Swiss service drill book on pontooning, by which it will be seen that the Swiss system closely resembles the Austrian one. The pontoons are very similar to the present Birago pattern, except that the Swiss have kept to wood, as in the original Birago construction, instead of using sheet iron as in the Prussian, Austrian, and Belgian service. By referring to Colonel Lovell's table (Vol. XII., *R.E. Professional Papers*, 1863), it will be seen that the Swiss pontoon is a little larger than the present Birago pattern, but not quite so deep. It is, however, lighter, the weight of two pieces of the Swiss being only 1,466 lbs., against 1,667 lbs. of the Austrian. But, compared with our present service pontoon, the Swiss one is very heavy. The latter is formed in two pieces, weighs 13 cwt., and has an available buoyancy of 13,875 lbs., taking only $\frac{3}{4}$ths of the total power of support. The English pontoon weighs only 7 cwt., and has an available buoyancy of about 12,500 lbs. The normal interval of our pontoons is 15 feet from centre to centre, that of the Swiss 21 feet 8 inches, the same as the Austrians. Following Colonel Lovell's table, the greatest possible load per foot run (taken at 110 lbs. per square foot*) for the Swiss pontoon would be 1,026, with a power of support of 639, if in two pieces, or of 1,030 nearly if in three pieces. This buoyancy may, however, be underestimated by me.

The English pontoon having only 9 feet of roadway, would not have to support more than 990 lbs. per foot run, for which it would have an available buoyancy of 833 lbs. If the buoyancy be allowed to within 5 inches of the top of the coamings, it would be 890 lbs.

In the vexed question whether it is better to carry the baulks on saddle-beams or on the gunwales, the Swiss and Austrians are on our side. Against us we have the formidable Prussians and the Italians, who adapted Cavalli's system after their experience in 1859. In our *Instruction in Military Engineering*, it is stated that "roadway supported on saddle-beams are less stiff to resist the current, and require more support from anchors than those where the baulks overlap. In the latter case also the effect of a concentrated load is more distributed, but longer baulks are wanted, and in rough water the roadway is apt to be too rigid." On the other hand, the saddle-beams are stated to allow of great lateral swaying and side rocking under continuous traffic, so that the Austrian engineers use tie-baulks. The Russians adopted a similar plan in the bridge across the Danube, thereby giving it some rigidity, but the Roumanians trusted to the saddle-beam arrangement, without tying down the baulks or connecting the boats, so that these were allowed too much lateral sway, and in consequence, it is said, their bridge failed. This important point in bridge construction seems, therefore, to need more investigation by the light of further experience. The system of joining pontoons together, end to end, must have considerable merits, as it has been adopted, I believe, in all the armies of the continent.

The head quarters of the Swiss pontoon companies is at Geneva, where there is a beautiful position at the junction of the Arno and Rhone for bridging operations. On the 12th September an inspec-

* This load is obtained by estimating the weight of infantry crowded at 100 lbs., and superstructure at 10 lbs. per square foot.

tion was made at this spot by Colonel Dumur, when a bridge of sixteen bays, carried by fifteen pontoons in two pieces, was made in forty-eight minutes, not counting the time for construction of the two landing bays; including this it took one hour and ten minutes to complete a bridge 125 yards in length. In the afternoon the bridge was broken up in thirty-seven minutes. A flying bridge was then constructed with a platform 19 ft. 8 in. by 23 ft., supported by pontoons in three pieces, capable of carrying 100 men. In crossing the river, which has a strong current, the anchors dragged a little, but the operation was quite successful.

The companies of sappers carry on the regular engineer work, such as water supply, construction and repair of roads, bridges, fortifications, &c. At the late autumn exercises they were employed, together with the engineer pioneers and infantry pioneers, in throwing up an intrenched position. There were two lines of works; the advanced line extended for about 2,000 yards along the edge of the plateau of Aclens, commanding the valley of the Venoge, and the second was on high ground in rear. *Plate* III. represents the right redoubt of the advanced line. The work was carefully defiladed in anticipation of an oblique fire from a position on the right. This work was designed by the engineers, but constructed by the infantry pioneers. The defences were completed by infantry and by the artillery of position. *Plate* IV. is a drawing of a more elaborate description, and may be taken as a type of the most advanced construction of field forts on the German model.

The companies of engineer pioneers are of recent formation. They are divided into two sections for telegraphs and railways, and have a total strength of 108 officers and men.

The telegraph section has four wagons for 4 horses each, two carrying the posts and uninsulated wire for the high line, one the insulated wire or cable for an underground line, and one the tools. There is also a covered cart (two horses) for the officer and battery. Ten kilometres of each telegraph wire, or twenty kilometres in all (about $12\frac{3}{4}$ miles) are carried by this section.

The railway section is employed on laying or repairing lines of railway, or railway bridges, forming ramps for unloading, in short on all services connected with the utilization of railways for military purposes. This section is accompanied by two special tool carts.

### Infantry Pioneers.

These men are generally recruited like the sappers among the artisans or mechanics and they pass through a technical training school for twenty-eight days, so that they are really sappers under another name.

There are four pioneers per company, or sixteen and one non-commissioned officer per battalion, fifty-one per regiment. For purposes of pay, rations, &c., they are included on the strength of their respective companies, but for technical duties they take their instructions from the divisional engineer officer. When their division is not assembled, the infantry pioneers are usually attached to sappers for repetition drill (biennial). They are also formed into detachments for work with regiments or divisions when required.

During the preparatory course the pioneers of infantry were formed into one corps for the purpose of being employed on the defensive works at Aclens, under the divisional engineers. Wagons of pioneers' tools (one to each regiment) accompany the park of a division.

During the manœuvres of the past year the infantry pioneers were provided with light portable tools on the following scale :—

1 shovel and 1 axe for each front rank man.
1 shovel and 1 pick for each rear rank man.

In addition each man carries a water bottle and roll of cord. The total weight of the equipment is 15 lbs. 13 oz. each for the front rank, and 15 lbs. 5 oz. for the rear rank.

The weight of the portable shovels is 4 lb. $9\frac{3}{4}$ oz.
" " picks is 5 lbs. 8 oz.
" " axes is 6 lbs. $0\frac{3}{4}$ oz.

## Administrative Corps.

Previous to the organisation of 1874 there was, properly speaking, no administrative corps. To every company of the different arms a "fourrier" or quartermaster-sergeant was appointed, and each battalion of infantry had its quartermaster. The commissariat staff furnished officers called commissaries to brigades and divisions, and all the supplies were obtained by special contract. It was in order to be independent of contractors that the administrative corps was created.

This corps consists of eight companies, one to each division in the élite, and the same in the landwehr. It comprises also all quartermasters on the staff, or attached to troops for purposes of keeping accounts, pay, &c.

Each division has, therefore, a company commanded by an officer with rank of major, whose staff consists of a surgeon and a quartermaster. The company is divided into two sections which are organised as follows :—

| | |
|---|---|
| 1 supply section. Total, 40 men. | 3 officers.<br>1 quartermaster-serjeant.<br>1 hospital attendant.<br>1 serjeant baker.<br>20 bakers.<br>1 carpenter.<br>1 serjeant butcher.<br>10 butchers.<br>2 soldiers of the train. |
| 2 store sections. | 4 officers (one a captain).<br>3 fourriers.<br>Store workmen, not belonging to the company. |

General total of staff officers and men—50.

| | |
|---|---|
| Each company has 1 tool cart, (2 horses).<br>1 utensil cart, (2 horses).<br>1 covered ,, ,,<br>1 field forge cart, (4 horses).<br>36 provision wagons (4 horses). | Total draught horses, 154. |

The men of this corps have to go through a course of technical instruction, including construction of ovens for baking bread, temporary storehouses, &c., in addition to which they go through the usual recruits' drill of a soldier.

I inspected the arrangements for baking bread which were very satisfactory. They had constructed three brick ovens about 13′ × 8′, and enclosed them in a shed, in which they baked bread sufficient for 5,000 rations. To supply the whole division the staff of bakers should have been nearly doubled. The cattle were all killed and cut up by the butchers of the section. All the cattle are killed by ball cartridge of Schulz powder (gun sawdust) which is put into a short barrel having a plate with three projecting pins. This plate is strapped to the horns of the animal, the three pins resting on its forehead. The cartridge is then fired by a light blow on a pin with a hammer and the beast drops dead. I saw this operation performed successfully on a large ox and it seemed a very simple, expeditious, and merciful way of killing the animal. I was informed that the time required to dispatch, skin, and cut up an ox does not usually exceed 20 minutes, and is frequently done in 18.

It is further the duty of these companies of administration to construct stores for provisions, and to transport the rations each day towards the principal centres, whence they are fetched by the wagons of the different corps. These wagons, as well as those of the commissariat, are at present obtained on requisition from neighbouring farmers.

### Sanitary Troops.

The sanitary troops of a division are commanded by the principal medical officer, who has the rank and title of lieutenant-colonel, under whom are the adjutant and a secretary of the divisional staff. The command comprises all the surgeons of the different corps, and all the hospital orderlies (infirmiers) and stretcher men (brancardiers) attached to these corps, as well as the ambulance wagons. The commanding medical officer appoints committees to examine officers and men who claim exemption from service on account of illness.

There is also a veterinary section.

### The Battalions of the Train.

The battalions of the train are of recent creation, and were formed in order to avoid the necessity of always having recourse to the system of requisitions, when horses or carriages are required. By Act 185 of the Military Law the Federal Government has, in an emergency, the power to lay hands on all the horses in the country by decreeing a *mise de piquet.* The effect of this is to make all horse proprietors responsible for their animals, and renders any one who sells his horse without authority liable to a fine of 500 francs. The horses are then all classified ; those unfit for service are released, and a selection made from those approved, the owners being indemnified for their use, or in case of loss. The horses, carriages, and drivers obtained in this way require organisation, and cannot be moved from one Canton into another.

A regular train was considered indispensable on the Federal corps being re-organised, and would, no doubt, serve to organise the transport obtained by requisition in times of general mobilization.

The battalion of the train, according to the law of 13th November, 1874, furnishes the necessary teams to the battalion of engineers, the ambulance, and to the company of administration.

As soon as a battalion of the train is called out, it takes its horses in part from the depôts maintained by the Confederation at the schools, and in part from the local contractors. This system furnishes good horses and trained men for the different corps as above, each of which has the necessary carriages for its transport.

## The Divisional Park.

The divisional park supplies the reserve ammunition for all arms. It also supplies reserves in material, men and horses for the brigade of artillery.

## The Train of the Line.

This is composed of men who go through the same course of stable instruction, &c., as the men of the battalions, but who are attached to the different battalions of infantry, and take all their orders from the officers of those battalions.

There is a non-commissioned officer and 6 soldiers of the train for each battalion. An adjutant, non-commissioned officer and soldier of the train are attached to the staff of the regiment; also a lieutenant and soldier of same corps to the staff of each brigade. These men are all in charge of the infantry transport, and take their instructions from the infantry officers.

## Discipline.

Article 212 of the Penal Code names the authority under which a court-martial can be convened. Although the punishment of death is abolished for civil crimes, it is retained in the army.

The Articles of War, decreed by the Federal Assembly, recapitulate the offences for which death shall be inflicted in time of war. Minor breaches of discipline are punishable by confinement, arrest, fatigues, drills, and punishment guards, suspension, or loss of rank.

A table is appended (Appendix C), extracted from the *Livret de Service*, with which every soldier is supplied, of the penal powers of different officers and non-commissioned officers at all times when under arms. Every such punishment has to be immediately reported and entered in the defaulter's sheet. No subordinate can claim to appeal against his sentence until after it has commenced.

The rules for salutes are very precise, and enjoin that all officers or soldiers on meeting should salute, the inferior or junior taking the initiative.

At the manœuvres men who were lying down after a march would spring up to attention on the approach of an officer, and were very particular in saluting foreign officers. Mounted men salute with their right hands to their caps, the same as infantry.

The general appearance and conduct of the men was soldier-like.

## Barrack Accommodation.

There are not many large barracks in Switzerland, and the only one I saw was at Thun, the great artillery school which accommodates

1,000 men. They were generally clean, well lighted, and fairly well ventilated. There was an open interior court to each block, with covered galleries running round the four sides on each floor on which the rooms opened. These covered galleries or landings serve for drill purposes in wet weather. There are 22 men for each room who have about 500 cubic feet each. The rooms have thorough ventilation, but the draught is along the length of the room, and the beds are placed along the side walls so that the ventilation does not fulfil modern sanitary requirements. The latrines are contained in a circular tower attached to each block with three stories corresponding to the barrack. The latrines are on the French system, consisting merely of a series of holes over a central vertical shaft, with two raised places for the feet. The places are screened by short partitions and flushed by water once a day. There are closets for non-commissioned officers. The ablution arrangements consist of a trough outside and several taps, but no basins.

I also inspected the barracks at the new musketry school at Fribourg. The latrine and ablution arrangements were similar to those at Thun. The allowance of barrack room per man is 14 cub. metres (about 494 cubic feet) for infantry, 18 cub. metres (about 564 cubic feet) for cavalry. The French give from 14 to 16 cubic metres. The cavalry are considered to require more space owing to the smell of the stables they bring with them. The officers' accomodation was of a Spartan character. The commanding officer had only one room, and the others were 3 or 4 in a room about 20 to 30 feet square.

### Staff of Federal Army.

The head quarters of the Federal army is Berne, and the following is the official organisation :—

A Military Secretary with three under secretaries—officers of the Army.

4 Heads of Services { Engineers and Infantry at Berne. / Cavalry and Artillery at Aarau.

| | | |
|---|---|---|
| 7 Heads of Departments, | Staff ... ... ... | 1 |
| | War Materiel ... | 2 |
| | Medical ... ... | 1 |
| | Veterinary ... ... | 1 |
| | Commissariat ... | 1 |
| | Auditor General... | 1 |

| | | |
|---|---|---|
| 7 Chief Instructors. | For Infantry | at Lucerne. |
| | ,, Rifle practice | ,, Fribourg. |
| | ,, Cavalry | ,, Frauenfeld. |
| | ,, Artillery | ,, Neumünster. |
| | ,, Engineers | ,, Sumiswald. |
| | ,, Sanitary troops | ,, Sarmenstory. |
| | ,, Administrative troops | at Thun. |

Also 8 District Instructors.

Each division is commanded by a colonel and there are also commandants of the various military circles, which vary from 6 to 12 per divisional district. All Federal functionaries are nominated for 3 years only, but they can be re-nominated, so that heads of departments are quasi permanent.

There are no general officers in the Swiss army, but the Federal Government have the power of nominating a general, in case of any emergency requiring the embodiment of several divisions at a time, General Herzog, returned to the rank of colonel on disembodiment of the army after the Franco-German war, though still given the title of general by courtesy. No foreign orders are allowed to be accepted or worn by officers or men of the Swiss army.

### Staff Corps.

The staff corps consists of 3 colonels, 16 lieut.-colonels or majors, and 35 captains.

The selection of officers for the staff corps is made by the Federal Council from officers of all arms who have been recommended by their instructors or superiors, and who have passed successfully through their first course.

There is a special railway division of the staff corps, selected from the railway officials, whose duty it is to prepare for the organisation of necessary arrangements for the transport of troops in the time of war.

The school for the head-quarter staff has two courses, one a probationary one of 10 weeks, and a second of 6 weeks.

At least six officers attend the annual subdivision work *travaux de subdivisions*, which lasts 2 or 3 months. This work involves the following course of study:—

Study of measures required for mobilization of the army, and its concentration on any given point of the frontier; also how a given point should be occupied under certain conditions, compilation of military statistics, history and geography of Switzerland, study of military institutions, topography of neighbouring states, &c.

## Appointment and Promotion of Officers and Non-Commissioned Officers.

Non-commissioned officers and soldiers who have been selected by their own officers (or by their instructors, if at a recruit school) as eligible for commissions, are sent to a school for officers. Those who obtain certificates of efficiency are then nominated lieutenants. For higher promotions a further certificate is required from the senior instructor, together with the assent of the candidate's superior officer, of the grade next above that to which he is to be promoted. There are schools for non-commissioned officers held annually for 5 weeks, at which all non-commissioned officers or soldiers who are candidates for promotion must attend.

G.G.

# APPENDICES.

## APPENDIX A.

### Statement of Military Instruction.

Preparatory course of gymnastic drill from age of ten. Course of target practice from age of eighteen to twenty.

The following is a summary of the courses of instruction for the different arms in the élite :—

| Service. | Instruction as Recruits. | | Course of Training. |
|---|---|---|---|
| Infantry | 43 days | ...... | 16 days every 2 years. |
| Cavalry | 60 „ | ...... | 10 „ annually. |
| Artillery—field batteries... | 55 „ | ...... | 16 „ every 2 years. |
| „ mountain „ | 55 „ | ...... | 18 „ „ |
| „ companies of position | 55 „ | ...... | 18 „ „ |
| „ columns of the park | 55 „ | ...... | 18 „ „ |
| Companies of artificers ... | 44 „ | ...... | 18 „ „ |
| Battalions of the train ... | 42 „ | ...... | 14 „ „ |
| Engineers | 50 „ | ...... | 16 „ „ |
| Sanitary Troops | 35 „ | | |

Administrative not yet settled.

There are also the following special courses of instruction :—

| | | |
|---|---|---|
| Staff school for officers of the General Staff | | 112 days. |
| Central School No. I. | for officers of all arms up to the rank of captain | 42 „ |
| „ II. | for captains of infantry newly promoted | 42 „ |
| „ III. | every 2 years for commandants of battalions of infantry | 14 „ |
| „ IV. | For lieutenant-colonels newly promoted | 14 days, of which a part is devoted to reconnaissance. |

Engineer officers selected for staff employment, and those for the technical duties of the defence of the country, go through a special military technical course, and in addition go through the General Staff school.

At the Federal Polytechnic school, and the higher Cantonal schools, there are special courses of instruction in subjects of military science, such as tactics, strategy, military history, &c. Pupils who pass an examination in these subjects with distinction may obtain commissions as 1st lieutenants on entering the service.

## District Schools.

| | | |
|---|---|---|
| The School of Musketry for officers of infantry newly nominated | 28 | days' course |
| Course of cadres for the infantry recruit schools ... | 8 | ,, |
| School for cavalry non-commissioned officers newly appointed and for 1st lieutenants recommended for promotion | 42 | ,, |
| School for artillery non-commissioned officers, &c. | 35 | ,, |
| Hospital school for hospital corps (infirmiers) who have completed their course as recruits | 21 | ,, |
| School for non-commissioned officers of hospital corps and stretcher-men | 21 | ,, |
| Special course for officers of administration and (fourriers) quartermasters. | | |
| Preparatory schools for officers of all arms. | | |
| Infantry every year in the divisional circle | 42 | ,, |
| Cavalry | 60 | ,, |
| ,, non-commissioned officers for promotion ... | 30 | ,, |
| Artillery officers | 105 | ,, |
| ,, non-commissioned officers | 63 | ,, |
| Engineer officers | 63 | ,, |
| Medical officers | 28 | ,, |
| Officers of administration | 35 | ,, |

N.B.—The days of entrance and departure are not included in the above periods.

## Landwehr.

Every two years there is an inspection of arms of the infantry. and the men take part in the annual musketry practice.

The other troops have an inspection of arms (one day) once a year.

Every man must have done at least two repetition courses before entering the landwehr.

# APPENDIX B.

## STRENGTH OF A DIVISION—WAR ESTABLISHMENT.

| | Troops. | | | Horses. | | | Wagons and Carriages. |
|---|---|---|---|---|---|---|---|
| | Officers. | N.-C. officers and men. | Total. | Saddle. | Draught. | Total. | |
| Divisional staff ... ... ... ... ... | 17 | 6 | 23 | 28 | 4 | 32 | 2 |
| Company of guides ... ... ... ... | 2 | 41 | 43 | 45 | — | 45 | — |
| Brigade of infantry ... ... ... | 167 | 4505 | 4672 | 67 | 84 | 151 | 39 |
| Brigade of infantry ... ... ... | 167 | 4505 | 4672 | 67 | 84 | 151 | 39 |
| Battalion of carbineers ... ... ... | 25 | 745 | 770 | 7 | 13 | 20 | 6 |
| Regiment of cavalry ... ... ... ... | 19 | 357 | 376 | 379 | 24 | 403 | 9 |
| Brigade of artillery (6 batteries) ... ... | 53 | 919 | 972 | 143 | 600 | 743 | 108 |
| Battalion of engineers ... ... ... | 19 | 374 | 393 | 19 | 114 | 133 | 30 |
| Divisional park ... ... ... ... ... | 16 | 307 | 323 | 46 | 238 | 284 | 73 |
| Battalion of the train ... ... ... ... | 13 | 292 | 305 | 46 | 374 | 420 | 108 |
| Ambulance ... ... ... ... ... | 35 | 172 | 207 | 8 | 106 | 114 | 38 |
| Compagnie d'administration ... ... | 10 | 41 | 51 | 3 | 154 | 157 | 40 |
| General total ... ... | 543 | 12264 | 12807 | 812 | 1421 | 2233 | 384 |

N.B.—Horses, wagons, and carriages of the train are not included in the general total, being accounted for in the return of engineers, ambulance and company of administration.

# STATEMENT OF PENAL POWERS.

| Punishments. | Corporal. | Sergeant and Fourrier. | Sergt.-Major Adjutant. | Lieutenants. | Captain of Company. | Major. | Lieut.-Colonel Commandant. | Colonel. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| *a.* For Private Soldiers. | Number of days. | | | | | | | | |
| 1. Fatigues ... ... ... | 1 Temporary Fatigue | | 3 | 5 | 8 | 10 | 14 | 20 | 1. Usual barrack fatigues, without consequent exemption from ordinary duty. |
| 2*a*. Punishment drills ... ... | — | — | — | — | 8 | 10 | 14 | — | 2*a*. Inflicted for short periods only, and at suitable times. |
| 2*b*. Punishment guards... ... | — | — | — | — | — | — | — | — | 2*b*. Is only given by the C.O. to men under instruction, and at proper intervals. |
| 3. Confinement ... ... ... | — | — | 3 | 5 | 8 | 10 | 14 | 30 | 3. To quarters, barracks, or camp without exemption from ordinary duty. |
| 4. Charge of police (arrests, simples) ... ... ... | — | — | 2 | 3 | 6 | 8 | 12 | 20 | 3 and 4 can be inflicted by inferior N.C.Os., but without fixing duration, and by giving in an immediate report to their superiors. |
| 5. Cells (arrêts forcés) ... ... | — | — | — | — | 4 | 6 | 10 | 20 | 5. The prisoner can at same time be put on bread and water on alternate days. |
| *b.* For N.C. Officers. | | | | | | | | | |
| 1. Nos. 3, 4, 5, as for privates | — | — | — | — | — | — | — | — | |
| 2. Suspension of rank ... ... | — | — | — | — | 8 | 10 | 14 | 30 | 2. Suspension of rights and privileges belonging to the rank, without deprivation of the distinctive marks. A captain can only inflict this punishment on the N.C.Os. of his company. |
| 3. Loss of rank ... ... ... | — | — | — | — | — | — | — | — | 3. Can only be inflicted by colonels and higher military authorities. |
| *c.* For Officers. | | | | | | | | | |
| 1. Simple arrest ... ... ... | — | — | — | — | 8 | 10 | 14 | 30 | 1. The officer only leaves his quarters for duty. |
| 2. Close arrest ... ... ... | — | — | — | — | — | 3 | 10 | 20 | 2. Does no duty. Gives up his sword. |
| 3. Confinement (arrêts forcés) | — | — | — | — | — | 3 | 10 | 20 | 3. Has a sentry before his door. |

# APPENDIX D.

## Swiss Pontoons.

The pontoon equipment is very similar to that used in the Austrian service, as described in Paper XIV., Vol. III., *R.E. Professional Papers (Occasional* Series). Two baulk wagons and one trestle wagon carry materials sufficient for 1,443 yards of bridge, which constitutes a bridge unit. Three other wagons accompany the pontoon train, containing a pontoon boat in two pieces and a row boat *(nacelle)*.

The pontoons are of wood, with iron fastenings, and of open punt-like build. They consist of two parts, end parts *(pontons becs)* and body parts *(ponton corps)*. These are coupled together by fastening, as in the Birago pontoon.

The end part is 15 feet 5 inches long, 2 feet 4 inches deep, 6 feet $1\frac{3}{4}$ inches wide at top, 4 feet $7\frac{1}{2}$ inches at bottom, and 2 feet 9 inches at bow. The body part is 11 feet 5 inches long, with width and depth as in fore part. The *ponton bec* weighs 6 cwt. 29 qrs. $10\frac{1}{2}$ lbs., the *ponton corps* $6\frac{1}{2}$ cwt. The anchors weigh 154 lbs. each.

The row boat *(nacelle)** is 29 feet 6 inches long, 1 foot 5 inches deep, 4 feet $9\frac{1}{4}$ inches wide at top, 2 feet 9 inches wide at bottom (in centre); it weighs 5 cwt. 9 qrs. $7\frac{1}{2}$ lbs. Pontoons are equipped as mooring pontoons *(pontons d'ancrage)* for letting go and lifting anchors. These are usually in two pieces (sometimes in three) as in *Fig*. 1, *Plate* V.

*Fig*. 2, *Plate* V., shows how the pontoons are put together and equipped when intended for use as boats to transport troops.

One man can work this boat, but the usual crew is 4 men.

*Fig*. 3 shows a pontoon of two pieces ready for forming bridge. If formed with three pieces, it would receive another end pontoon.

*Fig*. 4 gives an outline plan and section of a pontoon bridge in course of formation.

The normal interval from centre to centre of the pontoons is 21 feet $7\frac{3}{4}$ inches, the baulks are $3\frac{3}{4}$ inch by 5 inch scantling, 23 feet

* The use of this boat is to pick up anything that may get adrift or fall overboard during the operation.

1 inch long, and weigh 1 cwt. 19 qrs. 12 lbs., the chesses are 1 foot wide, $1\frac{1}{2}$ inches thick, 10 feet $8\frac{1}{2}$ in. long, and weigh 40 lbs. each.

The normal strength of a detachment to form bridge is as follows: 3 officers, one of whom is bridge commandant, 1 constructing officer, and 1 depôt officer, 12 non-commissioned officers, and 82 men, sub-divided into 8 troops. The chesses are racked down, and a hand-rail of rope is provided for safety.

*Fig.* 5 shows the arrangement for forming a cut, or bridge with a moveable portion for a passage *(ponts à portière)*.

The two connecting, or cut bays A B, are formed with baulks of $\frac{1}{4}$th normal length. Assuming A to be nearest the end of formation, the material of B would be laid on the central raft C, and those of A on the fixed part of the bridge. The raft C would then be swung down and moored below stream.

*Fig.* 6 shows how infantry bridges are put together.

The chesses are laid obliquely on three baulks, so that their corners project three inches beyond the outer faces of the baulks. End portions (*pontons becs*) may be used, as at A, in alternation with pontoons in two pieces.

The pontoons can be coupled together, as in Cavalli's system, in rafts, as in *Fig.* 7, or when used as boats for ferrying troops or stores across, as in *Fig.* 8.

*Fig.* 9 shows an arrangement for a bridge with a double roadway The first bay is shown resting on trestles, and the platform on the down-stream side is laid obliquely as far as the first pontoon.

This arrangement requires the pontoons to be composed of three pieces, and the bays are shortned by 5 feet 11 inches.

Rafts for flying bridges are constructed as shown in *Fig.* 10.

They are made in three sizes. The smallest size consists of a raft constructed with pontoons of two pieces, and requires the material of two bridge units. The medium size, as *Fig.* 8, has a double platform supported by two pontoons of three pieces, and requires the material of three bridge units. The large size has a triple platform (*i.e.*, in three widths), supported by two pontoons of four pieces each, and requires the material of four bridge units. The following gives a statement of strength of detachment which these flying bridges will carry:—

| | Infantry. | Cavalry with horses. | Carriages. | |
|---|---|---|---|---|
| | | | With team. | Without team. |
| (a) Small ... ... ... | 50 | 5 | | |
| (b) Medium ... ... ... | 100 | 10 | 1 | 2 |
| (c) Large ... ... ... | 150 | 15 | 2 | 3 |

The detachment for working the flying bridge is distributed as follows:—

One non-commissioned officer and four boatmen for each cable, one non-commissioned officer and fourteen or sixteen soldiers who are posted in three squads, viz., one squad of four men to each landing, one squad of six to eight men on the bridge as boatmen.

ON AS CONSTRUC

Plate I.

Fig I

*Plan of a Ba*

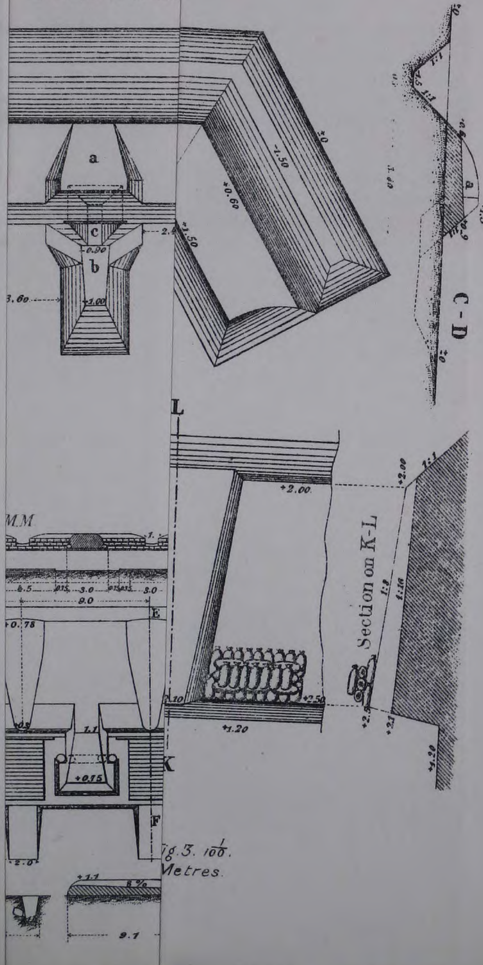


Fig.3. 1/100.
Metres.

# PAPER XIV.

## THE

# CONSTRUCTION OF MILITARY RAILWAYS

## BY THE RUSSIANS,

# DURING THE WAR OF 1877 AND 1878.

By Capt. M. T. Sale, R.E.

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Writing for Engineer officers, and dealing with a subject so full of professional interest as the construction of military railways during the last great war; it is not necessary to apologize for going rather into details.

The more brilliant and sensational achievements, on both sides, so enhanced attention, that the mere technical work of railway making passed at the time almost unnoticed.

And yet, amongst the many lessons and surprises given us by that memorable struggle, not the least useful and unexpected is the proof by actual accomplishment of what, under pressure of necessity, can be done in the way of speedy construction of military railways.

Had the question been put to any of us before the war, if it were possible in a few weeks, and during the very height of the military operations of a great campaign, to make, and in every way complete, a solidly constructed railway of nearly 200 miles in length, we should have been induced by all previous experience to answer in the negative.

It is true that in times of peace a very high rate of speed has been attained in the construction of certain lines, but this speed has only been arrived at by a carefully prepared organisation, and much practice on the part of all hands engaged.

Here, on the contrary, in the example given us by the Russo-Turkish War, we have a case where the construction of the railway was hurriedly determined on after the campaign was well in progress, so that no previous organisation of labour or collection of material was possible—all had to be commenced from the beginning; and yet in 100 days (of which 58 only were working days) from the date at which the final order for the construction of the railway was given, a single line, 189 miles long, ballasted, with several considerable bridges and station buildings, was made, fully provided with rolling stock, and opened for traffic.

This is a truly remarkable feat of engineering and administration, of which the Russians have reason to be proud. We, at least, may well ponder over it, and admire; for it contrasts rather forcibly with our previous performances in this direction.

Other lines of railway were made by the Russians during the war; these will be dealt with further on; for the present let us examine the circumstances under which this particular line of 189 miles was made.

Very early in the campaign the extreme precariousness, both materially and politically, of the Roumanian railway system, as the sole means of communication between Russia and the seat of war, was a source not only of inconvenience but of actual danger.

But the Russians hoped by rapidity of movement to get over the campaign so quickly as to obviate the necessity for perfecting the communications. This hope was soon shewn by the course of events to be fallacious, and it was determined to undertake several new lines of railway, the principal and largest being one to connect the Odessa lines with Galatz, and so to get a much more direct and strategically secure communication with the lower Danube and the Dobrudska (see *Plate* I.).

It was not until the 27th July, 1877, that a definite contract was given for the construction of this line.

The Russian administration having secured in a certain M. Poliatoff, a contractor of known energy and resource, very wisely left him much liberty as to the way of doing the work, contenting themselves with a succinct specification, which set forth in general terms the sort of railway required and gave certain minimum dimensions, but which did not enter into the details of any particular structure.

A line from Odessa to Galatz had long been desired for commercial reasons, and a preliminary project for such a line, starting from Bender on the Odessa-Kisheneff railway, had been prepared in the bureau of the Russian Railway administration some time before the commencement of the war.

When, however, the speedy construction of the railway was determined on from purely military considerations, it was found necessary to abandon altogether the project which had been previously prepared, and to take an entirely new direction for the line, because the trace, as first projected, crossed directly the main line of drainage and water partings of the country, and necessitated several heavy embankments which could not be quickly made, and when made could hardly be used immediately.

The original trace is shewn in the map (*Fig.* 2, *Plate* I.), as also the direction actually followed by the contractor.

It will be seen that in the new trace it was sought, by going round the heads of the streams which run towards the Black Sea, to avoid crossing, in direction approximately perpendicular to the water-partings, the undulating country which lies between these streams, and also to dispense with the necessity for passing over the low flooded ground in the valley of the Dneister near Bender, for which, according to the original trace, a protected embankment, $3\frac{1}{3}$ miles long, would have been necessary.

The new trace was considerably longer than the original one, but reduced both the earthwork and bridging to a minimum, so that by using gradients as severe as $\frac{18}{1000}$ in places it was possible to carry the line over the most difficult parts with less than 173,000 cubic yards of earthwork per mile, the average on the whole line being 1000 cubic sagenes per verst, equivalent to 19,150 cubic yards per mile.

The gradients are shewn in the section (*Fig.* 1, *Plate* II.), but they may be summarised as follows :—

| | Per cent. of whole line. |
|---|---|
| Level and gradients under $\frac{2}{1000}$ ... ... ... | 47·0 |
| Gradients between $\frac{2}{1000}$ and $\frac{10}{1000}$ ... ... ... | 41·5 |
| Do. $\frac{10}{1000}$ and $\frac{15}{1000}$ ... ... ... | 4·0 |
| Do. $\frac{15}{1000}$ and $\frac{18}{1000}$ ... ... ... | 7.5 |

The curves and straight line were in the following proportion :—

| | Per cent. of whole line. |
|---|---|
| Straight ... ... ... ... ... ... ... ... ... | 66·00 |
| Curves of 700 yards radius and over ... ... ... | 26·17 |
| Curves of radii over 350 yds. and under 700 yds. | 7·76 |
| Curves of radii of 163 yds. in terminal stations only | 0·12 |

The typical cross sections of the line are given in *Figs.* 2, 3, and 4, *Plate* II.; it will be seen that they provided, to a certain extent, for an eventual duplication.

The specification provided for a ballasting 10 feet wide, and $8\frac{1}{2}$ inches thick of gravel or coarse sand, as shewn in *Fig* 4 *Plate* II.

There were altogether 204 bridges, giving a total opening of 7,686 feet, and 88 culverts aggregating 5,922 feet. Of the bridges, 16 were of an opening greater than 70 feet, and amongst these were two of 175 feet opening, one of 259 feet opening, one of 280 feet opening, and one of 308 feet opening, in addition to the bridge over the Pruth river, near Galatz.

*Fig.* 1, *Plate* III., gives the cross section of the simple culvert, made in wood; *Figs.* 2, 3, and 4, give the cross section, longitudinal section, and plan of a double culvert, showing the diagonal struts, stone paving, and plank lining.

*Figs.* 5, 6, and 7, *Plate* III., give the type of bridge used in the Russian portion of the line and show also the stone pitching used to protect the embankments against wave action in floods.

In the Russian part of the line the bridges were all made of round logs, but in the Roumanian portion, squared logs were exclusively used except for the piers.

The bridges were entirely of wood, and were of a very ordinary sort, with short spans and braced pile piers. The points worthy of remark are—(1), the way in which the road-bearers are formed of two tiers of round logs bolted and dowelled together, so as to form compound beams, and tied to gauge and kept from capsizing by transoms notched in—(2) the manner in which the piers are arrayed in pairs capsilled together longitudinally, the capsills being corbelled out so as to relieve the road-bearers.

The bridge over the Pruth was the largest and offered the most difficulty, because it was necessary to make the bridge line very skew to the stream, in order to utilize an existing causeway as an embankment to carry the railway across the low lying ground on the left bank of the Pruth, near its junction with the Danube.

Moreover, it was necessary to provide a passage for the river traffic, so as to be able on occasions to give a clear opening of ten metres wide and a headway of six metres above highest level of the river, in order to allow paddle steamers to pass.

It would have been difficult to give this amount of headway by raising the height of the piers, even if the approaches to the bridge had admitted of it.

The difficulty was got over by making a sort of substitute for a turnbridge, or rolling girder, out of a pair of ordinary timber girders braced together, and so arranged that they could be floated into, or out of position by a raft formed of two pontoons, see *Figs.* 1 and 2, *Plate* IV., and *Figs.* 1, 2, 3, 4 and 5, *Plate* V.

This raft was furnished with a pair of trestles, one in each pontoon, made so that they could be readily taken to pieces, and provided with moveable transoms, in such a manner that the height of the transom above water level could be arranged to equal the height of the bottom of the girders above the surface of the river, whatever the height of the stream.

The pontoons were also provided with deck compartments, or tanks, which could be filled with water in such a manner as to cause the pontoons to sink a few inches; and having valves for discharging the contents of the tanks and so lightening the pontoons.

The mode of opening the bridge was as follows:—the raft being under the girders, having the tanks full, and the transoms adjusted to proper height, when it was desired to make the opening, all that was necessary was to open the tank valves and let the water run out, the pontoons and trestles rising, floated the girders off their bearings, and the whole affair (girders and pontoons) were warped out of the bridge line.

To close the opening or make bridge again, all that was necessary was to warp back the raft until the girders came into place against certain stops, and then to let water into the pontoons by valves provided in the bottom for that purpose. The pontoons quickly sank in the water and the girders soon took their bearing on the fixed piers.

The water in the bottoms of the pontoons was then pumped at leisure into the deck tanks by hand, so as to be in readiness for a fresh opening.

Four men sufficed for opening the pumps and the whole operation, opening and closing, took from a quarter of an hour to twenty minutes.

The whole arrangement seems rather clumsy, but under the circumstances it is not easy to see what else could have been done.

It will be seen from the drawings that the road-bearers are compound beams formed of squared logs, dowelled with hard wood dowels, and bolted together with vertical screw bolts.

*Fig.* 1, *Plate* IV., gives a drawing of the whole bridge; *Fig.* 2, shows the plan of the piers, (those out of the bridge line were driven in error) and *Fig.* 3 shows the relative position of the river bed, bridge, and approaches; *Figs.* 4 and 5 give end views of the piers, the latter being a pier of that part of the bridge which is on the curve.

*Fig.* 4, *Plate* V., shows the moveable girder and its bearings; *Fig.* 5, gives a plan of the upper surface of this girder in position;

*Fig.* 7, gives a cross section with elevation of the pier next the gap, and *Figs.* 1, 2 and 3, show the rafting of the girders.

Considering the great depth of the water in flood, and its liability to the action of ice, the bridge has rather a frail appearance.

The line being single, and it being specified that it should be capable of giving passage to at least seven trains per diem each way, it became necessary to establish a sufficient number of stations or passing places to enable this condition to be fulfilled.

The graphic time table in *Plate* VI., shows very clearly the positions of these stations or passing places, the former being indicated in capital letters.

There were in all 20 passing places (including termini), of which 15 were stations.

At the first opening, the full number of seven trains each way per diem were run, but subsequently under pressure of traffic it became necessary to run 12 trains per diem each way.

The graphic time table No. 2, in *Plate* VI. shows the rearrangement of the time table then made, but this amount of traffic taxed unduly the power of the line, and required a regularity in running which could hardly be maintained.

These two graphic time tables, taken in conjunction with the section diagram alongside them, are very instructive and interesting as samples of the mode of arranging the running on the simplest kind of line.

It will be seen from the time tables that it took about $23\frac{1}{2}$ trains to do the whole distance, giving an average speed, including stoppages, of only $8\frac{1}{4}$ miles per hour.

Fifteen watering stations were provided, fitted with the usual appliances.

The specification for the permanent way provided that rails of not less than 65 lbs. per yard, if of iron, or 60 lbs. per yard, if of steel, were to be employed. Those actually used were procured from various sources; they were for the most part of steel, a little over the weight specified.

All were of the Vignoles or flat-footed type, but the sections differed slightly.

They were spiked down in the usual way, two spikes being used to each sleeper.

The gauge being that of the Russian railway system (5 feet) the minimum length of the sleepers was specified at eight feet. They might be formed either of round logs of oak, fir, or deal, of a greater diameter than $10\frac{1}{2}$ inches, sawn in half, or of round logs under $10\frac{1}{2}$

inches diameter, but of not less than $8\frac{3}{4}$ inches diameter, flattened on both sides, so as to give a minimum thickness of not less than seven inches.

These sleepers were for the most part supplied from the Carpathians, not less than 1,980 per mile being used.

The total weight of the permanent way amounted to 135·5 tons per verst, equal to 204 tons per mile.

To work the line a rolling stock of 80 locomotives and 1,358 wagons and trucks were required. The locomotives were of the following types, viz :—

| | | | |
|---|---|---|---|
| Class | A ... | passenger or goods, 4 wheels, coupled ... | 9 |
| ,, | B ... | goods, 6 wheels, coupled ... ... ... ... | 49 |
| ,, | C ... | goods, 8 wheels, coupled ... ... ... ... | 12 |
| ,, | D ... | tanks, locomotives... ... ... ... ... | 10 |

Of the 8 wheels, coupled (class C), eight locomotives were of American make, these did not give satisfaction ; and of the tank locomotives, eight were Handyside's patent, that is to say they were furnished with the special Handyside rail grip, or brake, and were fitted with a winding engine and drum coiled with steel wire rope, so that they could be used as stationary winding engines, if required for drawing the wagons up heavy gradients.

They were only used as ordinary locomotives, in which capacity they gave much satisfaction by reason of their great steam producing power.

The wagons included,

73 passenger coaches,
812 covered goods,
470 trucks,

but there were only four specially fitted hospital or ambulance wagons.

The works were executed by a system of sub-contracts ; for the earthwork alone there were as many as 29 sub-contractors who, according to the terms of their contract, were bound to have an aggregate of 9,000 men and 4,000 carts at work on the line.

In addition to these labourers and to provide for contingencies, a special labour contract was entered into with other contractors for a further supply of 4,000 workmen if required.

Some difficulty was experienced in getting to work on account of wet weather, and the too numerous Saints' days of the Roumanian calendar ; but the arrival of the 4,000 additional workmen mentioned in the preceding paragraph gave such an impetus to the work that rapid progress was made.

The carriage of the materials for the permanent way from the depôts at either end was a very serious difficulty; unfinished gaps at bridges and in the earthwork prevented the line itself being utilized for the transport of materials, so that it was necessary to get together an enormous number of country carts for this purpose.

By offering a rate of 30 francs per cart per diem—a rate quite exorbitant, considering local prices—upwards of 5,000 carts were collected, and the transport of materials was rapidly effected.

Once the materials were got on the ground, the plate laying was pushed on so eagerly that, by pressing on to the work all the soldiers and unemployed men in the neighbourhood, a rate of 25 versts (15·7 miles) per diem was attained.

As soon as the line was completed by the contractor the Russian railway administration took it over, and it was worked in the ordinary way, the only difference being that the heavy traffic and insufficient balasting required an unusually large gang of permanent way linesmen.

The line was nominally commenced on the 27th July, 1877, but in fact it was not until the 7th August that the earthwork was attacked in earnest; on the 4th November the first train ran over the line.

Within the interval between the 27th July, 1877, and the 4th November, 1877, there were so many Saints' days, and so much rain that only 58 working days were left; in this short time there were executed:—over 6,000,0000 cubic yards earthwork, nearly 1½ mile run of bridging, over one mile run of culverts, 200 miles of permanent way collected, ballasted, and laid; watering places were built and sufficient station buildings, workshops, quays, and accessory buildings were constructed.

### Fratesti-Simnitza Railway.

The break in the communications of the main Russian army between the railway terminus near Giurgevo and the centre of operations in Bulgaria, gave so much trouble that it was determined to construct a line from Fratesti, a point in the Bucharest-Giurgevo line near Giurgevo, but out of range of Rustchuk, to Simnitza, to provide for the passage of trains across the Danube, between Simnitza and Sistova, and to continue the line from Sistova to a point at the foot of the Balkans, near Tirnova.

Definite orders for this purpose were given on the 15th September, 1877.

The line from Fratesti to Simnitza was actually made, see *Figs.* 1 and 2, *Plate* VII.; it was 40 miles long and its trace was for the most part along the left bank of the Danube, just above flood level, and out of range of the guns at Rustchuk, which made Giurgevo unavailable as a starting point.

The earthwork required was but slight, as the country was flat, the only difficulty being the passage across the lowland, where the Veda river joins the Danube. This necessitated an embankment two versts ($1\frac{1}{3}$ miles) long, and from 13 to 14 feet high, and a total length of 630 feet of bridge opening.

As the completion of this embankment and bridge would have delayed the opening of the line, a temporary, or dry weather passage, across the the Veda valley was made, irrespective of flood levels, and this temporary passage was afterwards replaced by the more permanent embankment and bridge.

The gauge of this line was that of the Roumanian railway system (4 feet $8\frac{1}{2}$ inches) of which it was a prolongation.

The completion of the whole line was delayed by the great difficulty experienced in bringing up the materials for the permanent way. The Roumanian line was choked up with military traffic, and transport by road was out of the question, as all the cattle of the country were taken up for the military transport, and the roads were so utterly worn out that the August rains had turned them into quagmires, in which thousands of draught cattle died exhausted.

For this reason the railway to Simnitza was not opened until the beginning of December, 1877, 50 working days from the commencement of the undertaking. A rolling stock of 29 locomotives and 810 wagons and trucks was provided for this line. Its graphic time table, given in *Fig.* 3, *Plate* VII., indicates without further explanation the working of the trains.

For the railway passage across the Danube, from Simnitza to Sistova, a system of flying bridges was adopted, somewhat similar to those which ply between Portsmouth and Gosport.

The train was run by means of a shifting rail ramp on to a long broad barge, which had a line of rails laid along the deck lengthways, and the barge was warped across by means of a chain cable fixed on either bank, and running on grooved rollers, worked in the barge by steam power.

The arrangement has no novelty; in fact the barges procured for the Danube crossing were some which had formerly been used on the Rhine for the same purpose, but were no longer wanted on that river since permanent railway bridges had been made.

There are, however, two points worthy of interest: one is the moveable ramp for running the trains on to the barge, and the other is the way in which the wire rope cables were laid. The ramp is shewn in *Figs.* 1 and 2, *Plate* VIII.

As regards the cable, the breadth of the river was so great that it was necessary to provide intermediate moorings, connected with the cable by bridle chains, to prevent it taking too great a curve from the lateral pressure of the swift current on the barges in crossing. The attachment of these bridles to the main cable would, if made in the ordinary manner, cause the cable to foul the grooved wheels when warping the barge to and fro. *Figs.* 3 and 4, *Plate* VIII., show the way in which this difficulty was got over. Two such barges were provided, the largest could take ten wagons, the smaller eight wagons each trip, and twenty minutes was required for each crossing.

These barges were brought up from the Rhine in pieces, by railway; they were put together and launched, but owing to the block on the Roumanian railway could not be completed in time to be of use at the Simnitza-Sistova crossing; they were transferred to the Rustchuk crossing as soon as that place was evacuated by the Turks.

The continuation of the same line from Sistova to Tirnova was commenced, and the earthwork was well in hand, but the difficulty of getting into position the materials for the permanent way was so great that it was evident the line could not be finished in time to be of use. It was therefore discontinued and left unfinished.

The trace of this portion of the line is shewn in *Fig.* 1, *Plate* VII.; it is of a total length of 75 miles. No considerable bridges were required, and the country up to the foot of the Balkans was favourable as regards the earthwork.

It had been contemplated to employ the Handyside engines on this line.

In addition to the three railways above mentioned, some minor works of railway construction were executed, amongst them being an arrangement for placing between Ungeni and Jassy (on the Russian frontier), the 4-feet $8\frac{1}{2}$-inch gauge line, in addition to the previously existing 5-feet gauge line, and carried on the same sleepers.

The object of this arrangement was to allow of either or both the stations of Ungeni and Jassy to be used as depôts for transferring stores and materials from the Russian broad gauge wagons to the Roumanian narrow gauge wagons, and *vice versâ*.

The distance between these stations was 22 kilometres.

The two gauges being so nearly the same, and the length of the sleepers necessitating placing the rails of each gauge as close to each other as possible, the junction of the sidings gave much difficulty.

*Fig.* 5, *Plate* VIII., indicates the difficulty and the ingenious, but rather complicated, way in which it was got over.

The particulars given in this paper have for the most part been derived from a book written by Mons. Lassar, a Russian Railway Engineer, and translated into French by Mons. M. L. Avril, published by Eugene Lacroix, of Paris, and priced 6 fr. 50 centimes.

It is clearly written and copiously illustrated, and is a book which cannot fail to be of much interest to Engineer officers.

12*th February*, 1880. M.T.S.

# PAPER XV.

## A REPLY TO PAPER XVII. BY MAJOR A. PARNELL, R.E.

ON

# "COAST FORTIFICATIONS AND THE NAVAL ATTACK OF FORTRESSES."

BY CAPTAIN J. T. BUCKNILL, R.E.

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THOSE portions of Major Parnell's paper about which there can be no difference of opinion have already been stated in the most convincing way by the late Sir John Burgoyne, by Sir Wm. Jervois and other high authorities on coast defences. The remainder of the paper, however, expresses views, the correctness of which is open to so much doubt, that I venture to make the following reply:—

At the commencement it is considered that the duties of our fleet in war "will lie mainly in the attack or blockade of an enemy's coast fortresses." This opinion is not qualified in the slightest degree. Evidently the duties of our fleet would depend on our enemy, and on the general scheme of our own attack and defence.

Again, we are informed that "the other maritime nations of the world can only in the defence of their fortified ports hope for success over our fleets." But they have also formed fleets of powerful fighting ships, and more than one possible combination might give our Navy plenty to do besides mere blockading and coast attacking operations. A few very superior vessels, well handled and fought, may prove more than a match for a number of slightly inferior vessels. We neither possess the most impregnable ironclads nor the most powerful guns afloat. The Italians have them.

The naval attack on Sebastopol is mentioned as an example of how little damage the old wooden men-of-war were capable of inflicting on shore fortifications; but further on it is acknowledged that the duty of the shore batteries is to prevent a vessel running past them, and in the American war it was several times demonstrated that wooden vessels, even in broad daylight, could run past heavily armed forts and batteries. The naval attack on Sebastopol is corroborative; for, although the loss of life was disastrous, the Russian shot and shell failed to sink or destroy any of our vessels.

Several pages are written to prove the accepted axiom that ships cannot engage forts with any chance of success. For instance, the Commissioners on the Defences of the United Kingdom said in 1861, "If the forts were to be constructed of granite with iron embrasures . . . . we are of opinion, that, considering the vulnerability of the ship's decks and the great superiority in respect to the steadiness of fire from a fixed platform, the ships could not attack the forts with any chance of success." The ships referred to are ironclads of the '*La Gloire*' class. As, however, the objects of the ships, in nine cases out of ten, is to pass the forts, the capture or destruction of the forts is a secondary matter.

Major Parnell considers that men-of-war are now even more vulnerable to shore artillery than in the days of wooden vessels, and bases this opinion chiefly on "the greater liability of modern heavily-weighted ironclads to be sunk." Surely he must be aware that the bulk-heads in the bodies of such vessels and the cellular arrangement of their double bottoms, formed by water-tight longitudinal and transverse frames, makes it a very difficult matter to sink them.

The acknowledged truism that fortifications form the best and most economical method of protecting our naval arsenals and coaling stations, is stated at some length; but it would be a mistake to suppose, with Major Parnell, that the utility of these fortresses is confined to the unlikely but possible event of "our experiencing a naval disaster at sea," or its equivalent "in smaller misfortunes." Again to revert to the report of the Defence Commissioners in 1861; "since the introduction of steam," they say, "the efficient blockade of an enemy's posts has become well nigh impossible." The advance in the science of artillery leads "to the conclusion that after an action even a victorious fleet would be most seriously crippled, and therefore a long time unfit for service. Added to these contingencies, circumstances may occur to prevent a fleet being at the required spot at the required time, or it may be disabled by storm, and it is possible that it may be overpowered." It will be observed that "the naval disaster at sea" is placed last, and follows a number of other and more probable contingencies. The great use of fortifications, when strong and well designed, is that they act as a deterrent, and thus often ward off an attack altogether.

"The idea of employing our Navy during war in securing our ports and in defending the communications between them," which Major Parnell says "has apparently been lately suggested," scarcely required the consideration he gave it. England's strong places have been fortified specially in order to obviate the necessity of such action, it being thoroughly understood by most people that our Imperial defences should enable us to send away, without fear, powerful fleets for distant enterprises.

Part (1) concludes by observing that "our Navy ought to hunt an enemy's ships from port to port, until they are either driven behind their fortifications, added to our own Navy, or sunk." This, no doubt, is a correct view, but it is somewhat at variance with the opinion in the previous page that "the attack of an enemy's ports would seem to be the primary object for the attention of our Navy."

Part (2) "On Forts and Batteries" deprecates the use of iron in coast defence. It is here considered that "under nearly all circumstances guns should be mounted en barbette," as being "the most effective" and "least expensive" arrangement, and because "the known inaccuracy of the fire from an enemy's ships' guns is then fully taken advantage of." Assuming the alleged inaccuracy of fire of guns afloat to exist, we are not told why advantage of it is not fully taken when guns are mounted ashore in other manners in the same situations. The relative efficiency of the different methods of mounting guns and of protecting them as well as their accessories, depends much, if not entirely, on the situation. In some places the guns *must* be placed behind iron or steel; in other situations they can be mounted en barbette; again, elsewhere they may with advantage be mounted on disappearing carriages. As regards economy, this also depends to a great extent upon the site, for it cannot be contended that any saving would be effected by the formation of barbette batteries on the sites of the Spithead Forts for instance. No one in their senses, of course, would think of doing it, and from a mere money point of view it would be a failure.

The statement that the chief feature of the barbette system is unrestricted training is not exact. On a straight front when good traverses are placed between each pair of guns, the training is restricted to about 130°, even when an indented parapet is resorted to. The 120° degrees of training, mentioned as a minimum, really, therefore, approaches the maximum obtainable when the guns "line the shores of reaches," which we are told by Major Parnell is the proper position for commanding channels and rivers, and not at the bends, so as to flank them. It is curious to observe that this opinion is held by one who thinks so highly of unrestricted training, because it would be natural to suppose that the advantage of placing modern long range guns so that each can fire at an enemy during his approach to, his passage by, and his retreat from the battery, when rushing the channel, would have been fully appreciated. This can be obtained with guns "en barbette" if the reaches of the channel, or river, make an angle of not more than 130°, and the battery be placed in the re-entering angle.

It should be observed, before leaving this part of the subject, that iron shields, each with a covered front and two ports behind which a gun up to 38 tons can be mounted, have been successfully applied in several situations. A total training of 120° is thus obtained; almost equal to that of barbette guns.

The opinion that the cost of the large modern guns is so great as to debar us from the additional expense of covering them with suitable iron shields seems illogical. The more costly and powerful the gun, the better should be the guard and protection, not only because the gun's repair or replacement is costly, but because its temporary disablement, even by a chance shot, would so greatly detract from the power of defence. For instance, what a disaster, if, shortly after the commencement of an attack on an important stronghold, in the defences of which two 100 ton guns were mounted, a chance shot disabled one of them.

Major Parnell thinks that "independently of the cost, the use of iron armour in coast fortification is not and never will be needed, and mainly on account of the want of precision of naval gunnery." The opinion of English Military Engineers is obviously different, or our present fortifications would not have come into existence. But in other countries, where iron has not as yet taken so important a place in coast defences, we find the same opinions expressed as those held in England. For instance, a Commission of United States Officers of high scientific attainments was appointed by the U.S. Government, in 1870, for the purpose of investigating this very subject. The Commission visited Europe expressly, and in their report we read: "For points . . . of very great importance, the artificial or otherwise contracted sites of which require the greatest possible concentration of guns, and which may be closely approached and enveloped by hostile fire . . . . a construction such as is adopted "at the Plymouth Breakwater Fort, is, in the present state of the art, imposed on the Engineer." In the same report we find it considered that for such sites as the "marginal positions on great rivers, navigable channels, or harbours, . . . . scarcely less important" than the first named sites "but not so liable to a concentrated and enveloping hostile fire," iron shields either in casemates or in open battery form a protection which is all the more necessary if the sites be contracted and of small command. The same report mentions that it is customary in England to mount guns en barbette when the battery has a command of at least 100 feet. Colonel (now Sir William Jervois) in his evidence before the Committee on Fortifications under construction in 1868-69, said :—"Considering the level of the Isle of Grain site, 50 feet above H.W.M., my opinion is that it is better to have the screen afforded by embrasures" than to make the battery en barbette. Referring to the proposed turrets on the roofs of the Spithead Forts, the U.S. Commissioners said "this arrangement is indeed almost a necessity, for although the height may be sufficient for a barbette battery . . . guns thus mounted would be exposed to reverse fire, shells, &c., to a degree sufficient to render any efficient service, except at very long range, impracticable."

Major Parnell says that the barbette battery is "much less expensive" than "iron shields, fronts and turrets"; but he gives no figures, and rests content with the mere assertion. It requires much qualification; even in favourable situations, barbette batteries must be much more expensive than formerly. The United States Engineer Board specially reporting on barbette batteries in 1868, said :—"If the necessity for traverses had not been previously demonstrated, the experiences of the late war against the rebels have, in the opinion of the Board, fully proved them to be indispensable to the efficient service of a battery which is liable to a heavy fire, whether such fire be direct, enfilade, or reverse. . . . The rebels frequently placed their guns singly, often at great expense and labour, and seldom more than two together, separating them from those to the right and left by high and thick traverses. Where guns were liable to a reverse fire, they covered them in the rear also, so that they were mounted, so to speak, in pits, the lowest part of the cover around them being the parapet over which their fire was delivered." It is evident that such an arrangement covers much ground, and when foundations form a principal item in the cost, the space occupied by each gun emplacement becomes a matter of importance. Moreover, when expense magazines and casemated cover are provided in the traverses and parados, and the mechanical appliances for the service of modern heavy artillery are fitted therein, the cost of a barbette emplacement approaches that of an armoured casemate, and this without taking into consideration foundations which in many places tell so heavily against any system which is not most economical in the space covered.

The objection to smoke in casemates is mentioned more than once in the paper, but the perfection of reliable range and position finders has, in many situations, to a great extent removed the difficulty. The observers will be placed at a distance from the battery, and away from the smoke. The gunners will obey certain definite orders, and fire their guns as quickly as possible through the smoke at objects often invisible to themselves; the position of the object, and therefore (from the tables) the correct elevation or depression and training of the guns, being telegraphed to the commanders. It is true that a range and position finder is one of those "refined and delicate" . . . "electrical and mechanical arrangements" for which Major Parnell expresses such misgiving; but the results at the trials being so good, it seems only reasonable to suppose that this class of instrument will act efficiently on service.

Major Parnell argues against the employment of turrets on sea forts, and says that the fact of an enemy's ship having passed a turret "would prove, so far, the uselessness of mounting guns at all in such positions." This is tantamount to saying that neither guns nor armour should ever be placed on the rear side of a fort! No doubt, as a general rule, the first duty of a fort is to bar a channel, but it does not follow that front fire is always the most effective for this purpose. Moreover there are some notable cases where the paramount duties of the forts are something quite different. For instance, the outer forts at Spithead were not made to bar the channel into Portsmouth Harbour, but to protect Spithead, and to prevent a bombardment of the Dockyard from the waters in their neighbourhood. The harbour is denied to an enemy by the defences at the entrance (*vide* report of the Defence Commission) and these were always considered to be sufficient to do so, of themselves, without any outer forts. The reasons for keeping an enemy, if possible, *outside* the outer forts at Spithead is to deny the Solent and Southampton water to him, and to prevent him effecting a landing on the northern shores of the Isle of Wight. These are certainly secondary considerations to the defence of our great naval anchorage and to the protection of Portsmouth from bombardment.

We are next told that the twin system which is usual in the mounting of guns in a turret is "barbarous," because in training one gun "you must lug round, not only the turret, but the other gun." In the Navy, however, simultaneous broadsides are rather the fashion. The above argument is antagonistic to such a mode of attack.

Again, the concussion inside a turret when struck by an enemy's shot is spoken of with much foreboding; but American sailors have survived it, and English soldiers may be expected to do the same.

The paper next informs the reader that iron structures afford little scope for the mounting of larger guns than those they were designed for. It is however notorious that heavier guns and thicker shields than those for which our forts were first designed have been mounted without much difficulty; the training of the guns being slightly decreased, which must always obtain, unless the ports be unduly increased.

In reply to the concluding sentence of Part (2) of the paper, it will be desirable to quote from the report on barbette batteries by the U.S. Board of Engineers already mentioned. The Board remarked :—"Everything indicates that the changes in guns and modes of maritine warfare, will greatly modify, and perhaps in great measure do away with, the use of guns en barbette. The Board had designed discussing this subject . . . . but defers doing so until it has further information."

Part (3) "On Obstructions" is really a diatribe against submarine mines. It commences with an extraordinary list, which claims to place "the various branches of coast fortification" in the order of their "relative importance." Booms and passive obstructions are placed at the head of this list, but no reason is given for so doing. Sir John Burgoyne in his memorandum, dated the 20th July, 1863, on "Mines and Obstructions" said, "The only passive obstructions applied of old were booms of chains and timber; they would certainly be troublesome and costly in their application, and were so often broken through by the enormous impetus of a heavy ship, that it would be hard to find on record where they had proved effective."

The Committee on floating obstructions, in their report on passive obstructions, expressed a strong opinion that booms "should always be placed under the protection of forts or batteries" and that "their position should be in rear of such defences, provided the guns can be so trained as to bear on the ships in contact with the boom."

These remarks apply to the form of boom of which Major Parnell evidently speaks, viz., one that will keep out big vessels; but the very fact of these defences being passive and requiring something *active* to protect them, places them in a lower rank of importance. Speaking generally, it will be conceded by most people that active are more potent than *passive* obstructions. It is very questionable whether large booms will ever be now resorted to. The double boom, with moorings and mooring floats, recommended by the above Committee and considered necessary (by that Committee) if any attempt of the kind be made to keep out the ironclads of the present day, would cost £38,300 per sea mile! There would be no great difficulty encountered in breaking such a boom, by means of charges placed at night, and fired from the enemy's boats. It would be almost impossible to prevent a determined foe from doing this, except by placing other obstructions and defences in front of the said boom, these additional defences being specially arranged with a view to keep off boats, or at all events, to place considerable difficulties in their way. But there is a much more economical method of defence. For about one quarter of the cost of the above boom, a number of submarine mines with their accessories could be purchased sufficient for the proper defence of a channel one sea mile in width; and, according to Major Parnell, who acknowledges that "no ironclad ship is likely ever to venture over waters where there is the smallest chance of a mine lying sunken," until the mines are rendered harmless, these mines form a more efficient defence than the four times more costly boom. They are better because less expensive, because their position is unknown to an enemy and their destruction by his boats is more difficult. So much is the last the case, that perhaps active defenders may repair and replace mines more quickly than the attacking party can destroy or remove them; the defenders performing their portion of the work with much less hazard and loss of life than the attackers.

The reason for placing *mines* last and *booms* first on the list is not therefore understood.

It is to be noted that the value of submarine mines is considered to be "chiefly of a moral nature," and this, although "no ironclad vessel is likely to venture" over mined waters :—*vide*, previous quotation.

In short Major Parnell considers submarine mines to be nearly as unnecessary as he considers iron forts to be.

In comparing land with sea mines it should be stated that the smaller liability of the former to get out of order is counterbalanced by the greater facility with which the latter can be replaced if destroyed by an enemy. Indeed, one of the strong points in submarine mining is the ease with which gaps can be filled in, and the defence strengthened where weakness becomes apparent.

*Guns* come next on the list; they doubtless should be first. *Works*, which are almost as necessary for the proper service of the guns as the ammunition, are placed separately and after the *torpedo vessels* and *armed launches*, each very useful, but not indispensable. It would perhaps have been preferable if the guns had been bracketed with their accessories.

In Part (4) "On Torpedo Vessels and Armed Launches" the opinion is expressed that "a boom, a battery of two 64-pounders, and a torpedo launch would form an efficient and economical defence for a small commercial harbour." There can be no doubt about the economy, but the efficiency depends upon the probable attacking force, as well as upon the width of the channel, and the ease or difficulty with which it can be navigated. A single unarmoured cruiser might, possibly, under circumstances very favourable to the defenders, be kept at bay by the above defence. But a cruiser will probably in future carry a torpedo launch (the *Iris* will carry two), in which event, if submarine mines were known to be absent, the cruiser would organize a night attack on the boom with boats, destroy a certain length of the boom, and in the morning steam past the two 64-pounders, and capture or destroy all that these guns were intended to protect; the torpedo boats neutralizing one another.

In Part (5) "On Coast Defence Generally" a very erroneous view is taken of the employment of gunboats. These unarmoured, and therefore extremely vulnerable vessels "it is thought . . . would be very useful . . . . for the protection of long stretches of accessible coast, lying between considerable ports and harbours," and that they "would be merely in the way" when employed "in the defence of great naval or commercial ports." The opinion usually held is quite different. Gunboats have been specially mentioned by men of experience in war, as likely to afford considerable assistance to the Portsmouth defences, their draught being such that they can be manœuvred in the shallow waters where the large vessels cannot follow them, and their size being such that they do not afford a good target to the enemy, whose fire will probably be directed against more important objects. To use them on the open sea in the manner suggested by Major Parnell, would, from their lack of speed, expose them to almost certain destruction.

In this portion of the paper it is suggested that the "heavier guns . . . should be on the lower levels because low elevation is disadvantageous, and the more powerful the gun is, the more capable it is cf fighting at a disadvantage." The plan generally pursued, however, is to mount the best guns in the best places, so that an enemy's vessels, armoured to resist the other guns of the defence, may receive the greatest possible damage from the heavy guns.

Major Parnell thinks that the "land defences of a sea fortress could hardly be too efficient" and fears an attack landward; but it is comforting to find in the next sentence that "the temporary loss of the command of the sea or ocean concerned" must first be sustained; and still more so, to turn back to the commencement of the paper where such a naval disaster is looked upon as impossible, for, "it is only in the defence of their fortress that our enemies can hope for success over our fleets!"

In Part (6) "On the Naval Attack of a Fortress" there is not much requiring remark. The statement that a fort is "finally offensive, its business being to sink the ship, not to protect itself," needs to be qualified. As before stated, the first duty of forts is, as a rule, to *stop* the ships. But no fort can do so of itself. This is now an acknowledged fact. There must be obstructions, active or passive, and the forts must assist to protect them. This is one of the principal functions of most forts and batteries; for when the obstructions cease to exist the artillery defences can be passed.

In conclusion it may not be out of place to observe that every Englishman should be proud of the armoured coast defences of the British Empire, and that every Royal Engineer should be specially gratified by the knowledge that those who designed them belong to the Corps. Such a feeling is considerably enhanced by the careful study of these distinguished men's opinions, and by a knowledge of the manner in which they have been carried into effect in the face of great difficulties, caused not only by the revolution which has occurred in the science of artillery during their erection, but by the fact that in the application of iron to permanent defences, they were treading on new ground.

J. T. B.

[*This Paper was received in October*, 1879, *but could not be printed owing to the pressure of other work*.—Ed.]

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