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PREFACE.

In presenting Vol. IX. to our readers we would draw their attention to Paper V., which gives an account of the Railway Operations in Egypt in 1882, by Major W. A. Wallace, R.E., and to Paper VII., on Narrow Gauge Rolling Stock, by Lieut.-Colonel J. R. Hogg, R.E., which will be read with particular interest at the present time, when the subject of railways best suited to field service is engrossing the attention of Officers of all branches of the service.

A melancholy interest attaches to Paper IV., on the Field Training best suited to our Army, apart from its intrinsic value, it having been written by the late Lieut. R. da Costa Porter, R.E., shortly before his death, and we know we are only recording the feelings of the Corps when we express our regret that this is the last paper we can receive from the pen of a contributor whose early death has deprived both the Service and the Corps of an Officer of great promise.

This volume contains a new departure in the War Game, from the pen of Captain G. S. Clarke, R.E., who has furnished us with a paper on the Fortress War Game, adapted by him from the German, and which should supply Engineer Officers with a fresh and constant opportunity of carrying on their professional training.

For the drawings attached to Paper VIII., the Report of the Fall of the Chimney at the Ripley Mills, Bradford, by Lieut.-Colonel H. C. Seddon, R.E., we are indebted to Mr. John Waugh, C.E., of Bradford, who compiled them for his expert evidence given before the Coroner's Jury. The drawings were first published with his report of the accident, drawn up for The Yorkshire Boilers' Insurance and Steam User's Company.

Colonel T. Inglis, C.B., R.E., has kindly contributed a further paper on Amour Plate Experiments, which brings the subject down to the end of 1883.

Great difficulty has often been experienced by R.E. Officers in keeping themselves up in the doings of our sister service, the Royal

Artillery; thanks to the kindness of Lieut.-Col. F. G. Baylay, R.A., we are now able to give our readers a short account of the recent developments in the manufacture of ordnance, which will be supplemented in our next volume by a précis of the results of the experiments against masonry and earthwork recently carried out at Dungeness and Lydd.

FRANCIS J. DAY, CAPT., R.E.,

Secretary, R.E. Institute.

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SUBJECT OF THE PAPER.

PAPER I.

NOTES BY A RUSSIAN ENGINEER OFFICER ON THE THEATRE OF WAR IN EUROPEAN TURKEY.

(Translated from the German by Captain J. W. Savage, R.E.)

Adrianople.

Adrianople (Pl. I.) lies mostly in a hollow on the left bank of the river Tundscha, at its junction with the Adra, from which point both streams unite under the name of the Maritza. The town is, except on the south-west, or right bank of the river, surrounded by heights. Adrianople is a large, populous town, in which fine, handsome buildings, like Selim's Mosque, the Residency, and other public buildings, stand, in the midst of small, insignificant-looking houses, and in which, as in every other Turkish town, miserable plaster, a dusty-looking bazaar, and the inevitable Turkish dogs are not wanting.

The fortifications of Adrianople consist of 24 field redoubts, which are built on the surrounding heights. The latter are so favourably situated for a girdle line of forts, and cover the town so well, that there could be no doubt about the proper sites for the works. Their distance from the town varies from 526 metres to about a kilometre. Their distance from one another is about a kilometre, except on the side covered by the Tundscha and Maritza rivers, where they are about $2\frac{1}{2}$ to $3\frac{1}{2}$ kilometres apart.

These 24 works are all built on the same model, but are at the same time suited to the requirements of each particular case. The Turks had for their main objects the creation of several tiers of fire, the separation of the artillery from the infantry, and the command of the ground on all sides, even towards the town, by artillery fire. For this purpose the artillery was placed in the middle of the works on a sort of cavalier, which the designer styled the 'Earth bastion à la Montalembert.' The details of this bastion often differ in separate works, it being sometimes quite small, for one gun only, with a diameter of 33 feet, at other times being designed for 6, 8, 12, or even 14 guns, with a diameter in the latter case of 57 metres (Figs. 1, 2, Pl. II.). In some works also there are double bastions, as in Figs. 3, 4. In Fig. 3 there is a second bastion inside the first, with a greater command—a sort of cavalier for a single gun, which is designed to sweep the whole circle. To suit the form of the ground, moreover, there are some semicircular bastions as in Fig. 4, some elliptical as in Figs. 5 and 7, or hexagonal, or, finally, some in the form of two bastions joined by a curtain, as in Fig. 6. The guns fire from deep embrasures. Solid traverses, about 5 feet higher than the crest of the parapet, are so arranged as to admit in most of the works of two guns, or less frequently three, being placed between them. The central traverse extends, as a rule, to the middle of the bastion, occasionally further, the remainder merely to the foot of the interior slope of the rampart. In the traverses are blindages and magazines. The superfluity of covered shelter in the Turkish works is surprising and very remarkable. It is not easy to pick out a single traverse in which there is not some kind of blindage. The traverses were, moreover, built in an especially solid manner, their interiors being entirely sunk below terre-plein level, so that they were not vulnerable from the side. The inner walls of the blindages were either revetted with thick boards, or with masonry or brickwork, and those in the valley of the Adra even with cement. In many of them there are ventilating shafts. The covering baulks are placed at the level of the ground or of the terre-plein of the rampart. There is first of all a layer of baulks of beech 1 ft. square, then over these a second layer of stronger baulks, then a layer of fascines, and finally a covering of earth 10 ft. thick, so that this covering may be considered as bomb-proof. Occasionally layers of fascines and baulks are to be found in the earth covering, similar to those in the Russian blindages at Sevastopol. Blindages, as in Fig. 3, less sunken and not having so much earth on the top, are quite the exception. Entrance is effected by steps sometimes made of stone, and it is either behind or at the side of the traverse. The interiors are spacious and lofty.

The interior slope of the rampart is from $\frac{1}{2}$ to $\frac{1}{3}$, so that the guns can be easily brought into position. Here and there short banquettes are placed between the guns, apparently meant more for look-out positions than for defence.

The entrances to the works are 4·2 metres broad, and when on the exposed side are covered by breastworks curved in trace, without ditches, having sometimes a gun-bank for one gun. This sort of covering to the entrance answers its purpose completely, having only this disadvantage, that it gives insufficient fire in the direction of the entrance.

Bridges across the ditches are hardly ever used; entrance is effected by means of a dam across the ditch and an opening in the parapet. A bridge across the ditch was only found in one work in Schumla. The bastions are surrounded by a covered way adapted for infantry defence. In this manner the infantry and artillery defences are kept separate and in tiers, the former being from the covered way and the latter from the bastions. In the case of the double bastion there are three tiers. The covered way, with its glacis-like parapet without ditch, must here be regarded as the line of defence proper, the bastion playing the part of cavalier.*

The trace of the covered way varies much, according to locality; it is chiefly pentagonal, but sometimes hexagonal with a re-entering angle; sometimes that of a lunette with two or three salients on the front side. The communication between the covered way and the interior of the bastion is inconvenient. Some of the bastions, however, have no covered way or ditch; these are for the most part constructed of earth dug out of the interior, or of materials brought from elsewhere. In those bastions which have a covered way the ditch always conforms to the latter and not to the bastion. In consequence, the berms are broad at the salients. None of the ditches have special flanking defence.

The command of the crest of the glacis-like parapet is $4\frac{1}{2}'$, of the single bastions $10'$, of the double bastions $17'$, of the parapet covering the entrance $5\frac{1}{2}'$. The thickness of the parapets varies from $14'$ to $21'$, the depth of the ditches usually $14'$. All the numbers given are average.

Two of the works are of especial strength, viz., No. 9, Kaik Tabia (Fig. 3, Pl. II.), on the east side of the town, and No. 14, Anias-Babà (Pl. I.), at the north-east extremity of the girdle line. Their trace is admirably suited to the form of the heights on which they are situated. Each of them consists of a double bastion, in front of which is a ravelin with high rounded salient, adapted for infantry defence: there is a covered way in front of the ravelin; thus four tiers of fire are obtained. In the interior of the ravelin there is a traverse with a wide and convenient blindage.

As before stated, the surroundings of Adrianople make it especially suitable for an entrenched camp, and, by a lucky chance, the positions for the works appear to be so dictated by Nature that there is no choice about it. These favourable conditions are wanting, however, in one place, and that is near No. 15, Tasch Tabia (Pl. I.). Here, instead of the long, easily-defended slopes, occur a number of small hills,

* In fact, the arrangement is similar to that in permanent works having a covered way. The only novelty in the arrangement appears to be its adaptation to small works with unrevetted ditches.—*Translator.*

small ravines, and watercourses, which make it very difficult to defend the foreground by grazing fire. Here, at the only difficult spot, the Turkish engineer failed to master these difficulties: and, be it specially noticed, that the naturally strong positions were well utilised and strengthened, while at the place where Nature had not been so careful for the security of the place, the engineers also had taken but little trouble.

The works of Adrianople were, with the exception of two or three, quite finished, but not fully armed, when the Russian troops appeared before the town, so that, when the place was captured, in the 24 works only 3 field guns, 2 12-pounders, and 6 24-pounders were found.

The taking of Adrianople occurred, as is known, without a struggle, for the panic-stricken Turks thought only of flight and not of resistance. But had it been necessary to take the town by storm, an obstinate resistance could not have been offered; for although the works around it were built on quite an original plan and were capable of defence, yet they were not very adequately supplied.

To take this town a regular siege would not have been absolutely necessary, as the ditches of the works were not very deep (not more than 14 ft.); the escarps and counterscarps were only of earth. Without any defence to the ditches they would have been easily escaladed if the storming columns had only succeeded in advancing without great loss. Then, again, the artillery of the works would have had to be silenced, which would have been all the more easily effected, as the guns on the elevated and clearly visible bastions would have been much cramped for room, and exposed to the converging fire of the Russian besieging batteries. It would have been certainly more difficult to have neutralised the infantry fire from the works. It would have been necessary to throw up some trenches at night by flying trench work opposite the attacked works; these would have been occupied by riflemen, in order to keep up by day an overpowering infantry fire on the works. Each succeeding night the trenches would have been advanced nearer, until they were about 100 to 200 paces distant. In these trenches the storming columns would have assembled for the purpose of assaulting the covered ways, and after driving out the defenders, pressing on into the bastions. If some of the works had fallen in this manner, the town could not well have held out longer.

The works of Adrianople were found, at the time when they were inspected, in perfectly good condition. Only the blindages in those forts which were near the town were found to have been destroyed. When Adrianople was occupied by the Russian troops, the order was given to level these works. The demolition began with the blindages, but the work of destruction was soon stayed in face of the eventuality that these fortifications might, in the sequel of the campaign, be of use to the Russian army.

SCHIPKA.

In advance of the Russian position at the Schipka Pass lies the 'Sweti Nikolaj' Berg (Pl. III.). It has a flat summit, surrounded by almost perpendicular rocky scarps, about 100 metres high, and is called the 'eagle's nest.' The sides of this mountain are partly wooded, and extremely steep. The road which leads northwards over Schipka to the Sweti Nikolaj begins to ascend gently from close behind Kazanlik. Immediately behind the village of Schipka it serpentines upwards, and the ascent is very steep and laborious up to the summit of the Nikolaj Berg. According to barometrical measurements, Kazanlik lies at a height of about 400 metres above sea level, Schipka village and Nikolaj Berg at about 600 and 1,500 metres respectively. Behind Nikolaj, during the memorable fights around these positions, three other heights were concerned, viz., the Volhynisch Berg and the heights crowned by the Central and Round batteries occupied by the Russians, so that at this point the Russian position attained its greatest breadth of about 840 metres. Behind these positions the only others in possession of the Russians were the road itself and the heights surrounding it, on which were batteries and trenches—as, for instance, Mortar Battery No. 2, Battery Dragomirow, Skorospielaja, and Potjagina.

The Turks held a semicircle round the main position on the Nikolaj Berg, and had, moreover, the advantage of possessing the commanding heights, viz., towards the east, Sosok, Sacharnaja Golowa or Woronije Gniezdo (sugarloaf or crow's nest), and Mayj Bedek; towards the west, Lisnoj-Kurgan (*i.e.*, forest grave mounds) and Lisaja Gora (the bald mountain). From these heights they could bring a converging fire to bear on the whole of the Russian position, as well as on the windings of the road.

The position of the Russians was most unfavourable here at all points, having neither sufficient frontal development nor depth. The batteries on the Nikolaj Berg and the three summits behind it had to deliver their fire simultaneously towards the front, flanks, and rear. The road communicating with Nikolaj Berg, commanded on both sides by the Turks, had to be protected, partially at least, at many points by several rows of gabions filled with earth, piled one on top of another. Moreover, at intervals along the road, trenches were dug opposite to the Turkish positions. Complete cover from the enemy's fire on the road was not to be got, notwithstanding that the road had been diverted at especially unfavourable places. There was nothing for it, therefore, but to move compact bodies of troops and ammunition columns by night. The strength of the artillery was nearly equal on both sides, but the Turks had the great advantage of an enveloping and commanding position.*

The flat top of the Nikolaj Berg was the only position of any extent in the Schipka Pass. Here only was it possible to organise any considerable means of defence, and fortifications were used unsparingly. There were 20 Russian guns in the batteries, trenches, and lodgments of the Nikolaj Berg. Where the ground was favourable the fortifications were not confined to the summit, but were arranged for the most part in secure positions on the reverse slopes, in order to gain partial cover against reverse fire. The soil was essentially rocky; the breastworks were made of the stones and mould scraped off the surface; the revetting material was exclusively gabions. The powder magazines were sunk as deep as possible under the traverses. Behind the trenches and lodgments of the infantry were huts and blindages, sunk as far as practicable below the surface, and covered perforce with hurdles, bushes, stones, and earth. Between the trenches and lodgments and the huts in rear of them, communicating trenches had to be made. All of these were naturally of the simplest and roughest construction, owing to the scarcity of materials and the rocky nature of the ground.

Amongst the fortifications on the eastern slopes of the S. Nikolaj Berg is the so-called Stalnaja (steel) battery, which was armed with the steel guns captured from the Turks. This battery was exposed to a very heavy reverse fire, and it was necessary to build parados, in addition to the traverses between the pieces, with passages only just wide enough to admit the guns into the battery; the entrances again were protected by a parados in rear; as that even was insufficient, a third solid high parados was added (Fig. 1, Pl. IV.).

On the Nikolaj Berg also covered communications were made to all batteries and lodgments, having landmarks made of stones or turf, to show the way at night or in the rain or snow.

North of the Nikolaj Berg, on the road, there is a broad, flat, low-lying hollow, which was used as the burial-place of the Russians who fell in the defence of the Schipka Pass. On this spot a white

* The Turks had, at the last, about 40 pieces, composed of 8 c.m. and 9 c.m. field and mountain guns, besides 8 mortars of large calibre. The Russians had 45 field guns, including 2 mitrailleurs, 1 mountain gun, and 4 heavy mortars.

marble cross now stands, with the picture of a saint, given by Her Imperial Highness the Crown Princess.

About a kilometre in rear of this place rises on the left of the road the Volhynisch Berg, which is covered by many rock-built fortifications. Many of the parapets of the emplacements consisted merely of gabions filled with stones, with stones again on the top of them. The parapets of the Sturmowaja Battery, No. 1, were (Fig. 2, Pl. IV.) constructed entirely of stone-filled gabions. Quite close to the road here were the Centralnaja and Kruglaja (round) Batteries, which were both under the Turkish fire from front and rear. The Centralnaja Battery consisted, for this reason, of two parallel parapets with traverses across (Fig. 3, Pl. IV.). The guns were moved from one embrasure to the opposite one as required : the flank gun had three embrasures. The Kruglaja Battery was similar, though more roomy and convenient. Further north the batteries do not seem so worthy of notice ; they are less numerous as they recede from the Turkish trenches. The ground improves continually towards the north. Three kilometres behind the Potjagina Battery is a modest little house, the head-quarters of the brave defender of the Schipka Pass, Lt.-General Radetzki, and, close behind, the road begins to descend to the Jantra Valley. The Turkish works exhibited more variety of form than those of the Russians; but they were not nearly so cramped for room, and had also much more material at their disposal. On the height, called Sosok by the Russians, there were merely infantry trenches of sunken profile, the parapet being revetted inside and outside with vertical hurdle-work. The frequent use of wicker-work and hurdles for revetting was justified partly by the covered and very well chosen position of the works, partly by the feeble fire of the Russian batteries on this point. On the Woronije Gniezdo mountain or Sacharnaja Golowa (crow's nest or sugar loaf) there was a battery for two mortars on the extreme summit, and further forward, on the reverse slope of a minor summit, an emplacement for a single mortar.

Both batteries had to be blasted out of the rock, as shown by the Sections. The upper battery is (see Section '*a b*,' Pl. III.) slightly retired behind the summit of the mountain. The crest line is at the level of the ground, the superior slope is counter-sloping, and made of stone rubbish collected from the surface, and the exterior slope revetted with hurdles. The height of the crest is about 10′. The lower single emplacement is sunk about 10′ beneath the surface of the rock, but has, however, on account of its lower situation, a stone parapet, about 6′ high, revetted on both sides with hurdles (Section '*c d*,' Pl. III.). On the left flank the hurdle-work had to be supported (Section '*e f*,' Pl. III.), and, in order to obtain better cover, filled gabions, lying on their sides, had to be placed on the top, close to the crest. The infantry trenches consisted here of shingle revetted with hurdles; the thickness of the parapet was mostly 3′, but occasionally $1\frac{1}{2}'$ (Sections '*g h*' and '*i k*,' Pl. III.). In order to make room for the riflemen in the lower trench, a ledge had to be first blasted out along the slope (Section '*i k*,' Pl. III.). Between the works on the Woronije Gniezdo mountain and those on the Mayj Bedek, there was on a flat summit a battery for two guns. The latter was of sunken profile, had the cheeks of its embrasures revetted with hurdles, and a blindage conveniently placed under the roots of a large tree.

On the Mayj Bedek mountain stood a Turkish battery, called by the Russians Dewjatyglazka (nine-eyes), which had at first nine and afterwards eight embrasures on one straight face. The gun-portions of this work were ranged close alongside one another for want of space. Between the guns were blindages, as in Sections *a b*, *c d*, Pl. III. The thickness of the parapet was about 6·3m. The slopes were revetted with hurdles. On the side unexposed to the fire of the Russian batteries were a number of earthen huts. The construction of these huts was very simple and effective. They were so cut in the slope that the back appeared to be completely sunk below ground; the sides were half-covered, and only the front, in which were the windows and doors, was exposed. The side walls consisted chiefly of hurdle-work, daubed with clay; the roof was generally covered with hurdles, sods, and earth.

Besides these there were some huts more solidly built, with sod walls, roofed with tiles. There were ovens in most of them, so that the Turks lived in comparative comfort in these positions, which were nearly always wooded, whilst the Russians, on their barren positions, were exposed to all the hardships of an especially severe winter during the protracted struggle for the positions on the Schipka Pass. On the way from the Schipka village to the S. Nikolaj mountain were some excellently placed round rifle-pits for one or two men, having a high parapet completely covering the men, and loopholes revetted at the sides with stones (Pl. III.).

(Not 500m. to the south of the slopes of the Nikolaj mountain, on the stony pinnacles of which still lay the bodies of many of the bold Turks whom Colonel Ott had himself seen attacking on the 17th September, the Turks had placed a mortar battery and a number of trenches. The narrator mentions the remarkable contempt for death which was shown by the men staying in these works, when completely seen into from above by the Russians, and under their effective artillery fire.)

On the Lisnoj Kurgan Berg, the Turks had built in terraces a solid mortar battery for five pieces. On the upper terrace they had placed three mortars, and on the lower, which was 4′ below it, two; the parapet of the front portion of the battery was about 14′ above the platform. The interior slope was revetted below with stones and above with turf. At the foot of the exterior slope was a row of gabions. Along the left epaulement of the battery a ramp led to the lower platform, and along the right was a high banquette; under the left was a magazine entirely blasted out of the rock. In this magazine, as well as in many others of the same sort in the Turkish works, a number of projectiles were found at the time of their inspection. But the Russians had already withdrawn the pieces from the works. On the Lisnoj Kurgan there was also a battery with embrasures, the interior slope of which was, in like manner, revetted below with brushwood, above that with sods, then with timber baulks, and finally with hurdles. The height of the parapet was 13′. Almost the whole of the space between the Lisnoj Kurgan and Lisaja Gora was taken up with earthen huts, capable of sheltering a very large number of troops. These long lines of huts were covered by trenches and batteries against probable attacks by the Russians.

Timber baulks were used for most of these buildings. Here the Turks used simple breastworks of stone rubbish revetted on both sides with hurdles, with logs of timber on the top, as shown in Figs. 5, 6, 7 and 8, Pl. IV. These made loopholes of themselves, either on account of their crookedness or their special arrangement. Entire breastworks were even made of logs covered in front with earth. One of the batteries there was built in opposition to all the rules of field fortification. This battery had extraordinarily long and narrow embrasures. The width at the mouth was 2′, that at the neck 1′, the depth 8′. The cheeks were revetted with hurdles. The battery was built with the object of sweeping the windings of the road to the Rajska Dolina valley. The guns in this battery were always loaded and laid on the aforesaid road. As soon as troops or trains of wagons appeared a lively fire was opened, which made the use of this communication especially difficult and dangerous. In order to cover these guns as well as possible from the enemy's fire, the Turks had placed them behind these long, narrow embrasures, which could only be seen into from the particular windings they bore upon, and could with difficulty be descried from other positions at the side. There is no doubt that these embrasures could have been easily destroyed by three or four well-aimed shots; but the Turks knew how to make them well-nigh invisible, owing to their peculiar construction.

On the spacious summit of the Lisaja Gora, two lunettes were thrown up, having no special peculiarities.

We here extract from the account by Colonel Ott, of the Swiss Engineers, a sketch of the ground south of the Sweti-Nikolaj (Fig. 9, Pl. IV.), which is not to be found on the Russian plans. According to this, the two redoubts, *c c*, were built by the Turks on the Schipka Road, and the batteries, *b b*, on the heights on both sides.

The village of Schipka numbered 800 houses and 3,000 to 4,000 inhabitants before the war, but was razed to the ground; only the church remained, which was used as a store.

The intrenched camp south of the Schipka lies quite in the plain, and consists of 16 works, of which some are fortified tumuli; but most are round or oval redoubts.

A large tumulus 40m. in height, 1km. south of the village, and commanding the windings of the road of ascent with its fire, forms the centre of the northern front, where the ground rises gently towards the village. It is organised for 8 guns en barbette, and has a wide road communicating from the battery to the rear. In front of the summit are two shooting lines for infantry.

In front lies a rectangular redoubt organised for artillery and infantry defence; to the east a small tumulus with sunken ramps and gun emplacements; to the west three tumuli close to one another, all united by strong trenches for infantry and covered communications, with batteries between. The whole line commands most favourably the exit from the defile, and enfilades the windings of the road.

The interior slopes of the parapets are well revetted with fascines. The entrance is carefully arranged in Turkish fashion. The main line has passages for advance, which are specially covered and traversed. Behind the tumulus are the wooden huts of the general's quarters, and further within the camp wooden and earthen huts in large numbers, as well as field ovens. The redoubts in the plain are of small size, some arranged only for infantry defence by one company, some with gun banks for 1 to 3 guns per work. The parapets have a command of 2·5 to 3 metres, are throughout 4 metres thick, and have ditches for the sake of providing sufficient earth. The guns fire through embrasures 1 metre deep. The interior slopes are revetted with hurdle-work. All these works, on the flanks and rear, were of simple field construction, not specially strengthened by obstacles or lines in the intervals, and apparently not calculated for such a large circuit as it was.

Plevna.

In the 6th and 11th numbers of the year 1878, the 'Mittheilungen' contained detailed information respecting the fortifications and fights round Plevna, accompanied by sketches of the sites of the fortifications, and a large plan of the surroundings of the place. The double number, 7–8, contained also an illustrated notice of the Roumanian attack on the Grivitza redoubt. Keeping this in mind, we extract from the 'Russian Engineer Officers' Journal' only such details as did not appear in that publication.

The town itself had not suffered in the least from the fire of the Russian guns, as the Turkish fortifications were situated at a great distance away, at many points as much as 7 kilometres.

They were all very well adapted to the ground; artificial obstacles were, however, in no cases made use of. The Turks seem to have thought the latter quite superfluous, as they had unbounded confidence in the irresistible power of their infantry fire.

The distribution of the Turkish fortifications round Plevna was as follows: on the north and north-west, and also in the district between the river Wid and the Grivitza brook, was situated the Opanec Group. The latter consisted of eleven works of different shapes and sizes, from circular emplacements for a single gun (Fig. 1, Pl. V.) to the large central redoubt shown in Fig. 4. These works had to look principally towards the north, but they could easily bring the whole of the valley of the Wid under their fire.

On the north, at a distance of $1\frac{1}{2}$ kilometre from Plevna, was the lunette Suleiman Pasha (Fig. 5, Pl. V.), redoubt 47.* From the latter extended in an easterly direction, along a narrow ridge, and as far as the redoubt Osman Pasha (redoubt 17*) a trench 5 kilometres long, from which it was possible to command very effectively the northern approaches to Plevna.

In the middle of this ridge the highest portion was crowned by yet more fortifications for its better defence. The trench itself was strengthened here by advanced rifle pits. A second trench, parallel to the first, was constructed, with its parapet thrown up towards the south. Between the two trenches were many earthen huts. From the eastern end of this place of arms up to the Osman redoubt the trench had parapets on both sides, and was of considerable depth.

The group of defences east of Plevna consisted of works of various strength, and in the first line on both flanks were the redoubts

* These figures refer to Plate II., Vol. V., *R. E. Professional Papers* (Occasional Papers Series).

Tschorum (Fig. 6, Pl. V.), No. 4,* and Ibrahim Bey (Fig. 7, Pl. V.), No. 1,* called by the Russians the 'Dead Man's redoubt,' and between them a trench with rifle pits in front of it. Behind this first line was a second, having on its left flank a battery, and in the centre a long line of defence in the form of a bastioned front, armed with guns; on the right flank a lunette. Further in rear was the hexagonal Arab redoubt (No. 8 or 7), which could be regarded as the 'réduit' of this system of trenches and redoubts. From this group to the Tutschenitza group extended trenches with a redoubt (No. 10*) in the middle. In a southerly direction from Plevna lay, on the Zelenaja Gora (Green Hills), the Krischin group, consisting of three redoubts (Nos. 23, 19, 24*), which were connected by trenches, in front of which others were pushed well forward into the foreground.

Towards the west of Plevna the extensive mountainous ground was defended by very strong redoubts, arranged on the circumference and at the centre of a semicircle (Nos. 13, 26, 25, 20, 21, 22, 27, 28, 29, 30, 31*). This fortified semicircle was connected with the Opanec group by a line of trenches (battery and fortified camp); with Plevna by two lunettes (Nos. 11 and 12) joined by a trench; with the Krischin group by the redoubt Junus Bey (No. 14*), in front of which was a lunette (No. 15*). After the unsuccessful attack of the 30th August, immediately on the arrival of Adjutant-General Todleben, steps were taken for a close investment of the Turkish entrenched camp.

The investment line, consisting of trenches, infantry and artillery emplacements, lunettes and redoubts, which in many cases were arranged in several lines one behind another, was about 70 kilometres in length. Its average distance from the Turkish line was 500 to 1,000 metres. At two points these two lines approached very close to one another, and especially towards the south on the Green Hills, where the distance between them was 80 metres, and on the east near the Osman redoubt (Grivitza redoubt, No. 2*), against which the Roumanian troops had attacked by systematic approach.

The left lower bank of the Wid was well commanded by the fire of the works of the Opanec group; on that account the Russian investment line was here retired to about four or five kilos. from the Turkish, and required especial strength and resisting power against the possible attempt of Osman Pasha to break out.

* These figures refer to Plate II., Vol. V., *R. E. Professional Papers* (Occasional Papers Series).

A closer inspection of the style of construction of the Turkish works shows the great value they attached to the power of their infantry fire, and their endeavours to make it as damaging as possible to the Russians, whilst protecting themselves from fire. They attained the first of these objects by successive tiers of fire, and the second by numerous traverses. In order to obtain several tiers of fire they generally placed along the brow of the slopes several rows of trenches, one behind another; they moreover provided for two tiers of infantry fire in their works, either by cutting out a banquette in the counterscarp, as in Profile 3, Fig. 3, Pl. V., or by having an advanced trench, $3\frac{1}{2}$ ft. deep, 6 ft. in front of the ditch, as in Profile 7, Fig. 7, Pl. V.

With regard to vertical defilade the Turkish fortifications were very instructive; since, in presence of the steep angles of descent of modern projectiles, it is out of the question to try and cover the trench entirely by means of the front parapet, their works will be seen to be crowded with traverses (Figs. 2 to 7, Pl. V.). They are cruciform, parallel, interrupted, long, short, cut asunder, joined together, prepared for defence, and not prepared for defence. One of the larger redoubts of the Opanec group is quite singular in this respect (Fig. 4, Pl. V.). Its traverses are, in fact, so numerous and so irregular that they form a labyrinth in which one could almost lose oneself. By means of such a superfluity of traverses, having such different positions, the garrison could easily find shelter from fire from any direction whatever. These traverses also gave a good opportunity for the construction of covered blindages, huts, &c. Natural mounds were often utilised as traverses by excavating behind their slopes (Fig. 5, Pl. V.).

At Plevna the Russians also used traverses inside their works, and if mounds of earth occurred in the interior, these were utilised for the purpose of obtaining better cover (Fig. 10, Pl. V.), by trying to excavate under them. The profile of the Turkish works at Plevna was that of strong field-works: the parapet not higher than 10 feet, the thickness of the parapet not more than 15 feet, the ditches up to 9 feet in depth, the escarps and counterscarps steep. Closed works were the rule. The entrances were for the most part traversed, and only occasionally protected by small outworks; there were, further, a very large number of blindages, and covered shelters in the traverses. For the revetment of the slopes sods were mostly used.

A comparison of the nature of the Turkish, Roumanian, and Russian fortifications at Plevna was especially interesting. The Turkish works were throughout most happily adapted to the ground, and were, moreover, distinguished by solidity and size; apparently an immense amount of material and considerable labour had been expended on them.

The Roumanian works were likewise large and massive, but they were less skilfully planned, and had some grave defects. Before the Osman redoubt the whole foreground was covered by the Roumanians with very numerous trenches, of which many were quite superfluous. They opened also a mine attack against this redoubt, and drove a wood-cased gallery of considerable height and breadth right up to the enemy's lines, nothing daunted by the difficulties accompanying this undertaking. Fig. 9, Pl. V., shows a Roumanian redoubt thrown up near the Opanec group, in which the awkward position of the insufficiently long traverse in the interior strikes the eye. The reduit again is not suitably placed, being so low down that the attacker, once having taken possession of the outer parapet, could have completely seen into its interior and rendered it untenable. Equally objectless also is the hook-shaped outwork for the defence of the entrance.

The Russian works were very well adapted to the ground, had dimensions entirely suited to their requirements, and were made abundantly strong without incommensurate labour. Here follows the Penzenski lunette (Fig. 10, Pl. V.), as also a half-sunken siege battery (Fig. 11, Pl. V.). The design of the former included two tiers of infantry fire; judiciously placed traverses surrounded the gun-banks, and good traverses, half sunken, protected the interior, which was excavated to a depth of 2 ft. The parapet of the siege battery was only 5 ft. high, but loading trenches were dug out along the traverses for the gunners. To give covered communication between the guns, there was a trench along the rear of the battery, from which ramps led up to each gun. The traverses were blinded. These sort of batteries were built and armed in a single night.

Rustchuk.

Rustchuk is situated on the right upper bank of the Danube. The fortifications (Pl. VII.) exhibit in plan a lengthy form. The enceinte of this town consisted of several bastioned fronts, with long curtains and small bastions; * the masonry escarps were covered by a glacis without covered way. Facing towards the Danube were simply some batteries and trenches. Outside the enceinte 21 works* were built

* According to Ott, 10 bastions of 5 to 10 guns, in the curtains five stone gateways, the fronts up to 400m. side without ravelins, ditches 3 to 4m. broad, blindages none.

at a radial distance of $\frac{1}{2}$ to 4 kilometres, and about 2 kilometres from one another. They were throughout favourably situated on the summits of the surrounding heights, and apparently built at different periods. Their character was that of field works: the slopes of the ditches were not revetted.

The various directions of the traverses in these works are also very remarkable. Fort Tschelibi, for instance (Fig. 1, Pl. VI.), had a great number of traverses traced in different directions. Their height reached 14 ft., as also did that of the bonnettes. Under the traverses were posterns for unimpeded communication and many blindages. The Turks were not content with inner traverses only, but often employed them to cover the guns: thus, in Fort Achmed Eyub (Figs. 2 and 3, Pl. VI.) traverses extending the whole breadth of the rampart are placed on both sides of the guns.

In the work Tschesmy (Fig. 4) the guns were surrounded on all sides by traverses and parados, in which were shelters and magazines.

Whilst the Adrianople works had in no case defended ditches, some of those at Rustchuk were so defended. Thus, two of the ditches of Fort Tschelibi (Fig. 1) were defended by a sort of blockhouse at the salient, but only for infantry fire. There were no posterns to communicate with the interior of the work, and access was therefore difficult. In Fort Achmed Eyub (Fig. 2) there was a salient and two shoulder caponiers. Fig. 5 shows a special arrangement. Here there was a sort of small bastion at the salients for a single gun. These guns, for which two or even three embrasures were made, had a very great sweep (over 180°), and were well covered on three sides.

The profiles of the works round Rustchuk had, with the exception of Lewen-Tabia, no unusual dimensions, the average height of the parapets being 12 ft., and the depth of the ditches 10 ft. The thickness of the parapets was, however, considerable in all cases, being from 20 to 30 ft. As examples of special profiles may be mentioned two of the faces of Fort Kuink-Tabia (Fig. 5, Pl. VI., profile 2), which permitted of three tiers of infantry fire, and the faces of Fort Kadi-Tabi (Fig. 6, Pl. VI.), which, instead of a glacis, had a breastwork with abattis in advance of it.

Lewen-Tabia (Fig. 8, Pl. 6) is large, and as regards its armament, the strongest of the line; its trace is so irregular that it is difficult to describe; it is a sort of hornwork, having on one side a kind of tenaille front, and on the other a blunted redan (Halb-redute). The bastion and the redan had high command, and a sort of cavalier was erected on the broad rampart of the curtain which faced the entrance. Under the rampart was a colossal casemate, and under the rampart of the rear face a long blindage. The command of the crest of the parapet was 21 ft., and the depth of the ditch nearly the same.

Some of the other Rustchuk works are noteworthy, viz., the lunette Chydir-Baba (Fig. 9, Pl. VI.) and Owa Tabia (Fig. 7, Pl. VI.), both of which had covered ways; the battery Kutschuk-Kirdan, on the banks of the Danube, in which the guns (Fig. 10, Pl. VI.) were arranged in several groups, protected by traverses and parados, because they were exposed on many sides to the enemy's fire, and had to deliver their own fire in several directions. Forts Achmet Eyub (Fig. 2, Pl. VI.) and Arab-Tabia (Fig. 11, Pl. VI.), apparently the latest constructed, resembled in form those of Adrianople.

The armament of the Rustchuk works was very mixed; near a Krupp gun was often to be seen a smooth-bore shell gun.* One thing is remarkable, which certainly would have been awkward in the event of a siege, viz., that the Rustchuk works had no drinking water, and the garrison would have been dependent on the rain water collected in the excavations.†

Schumla.

The intrenched camp of Schumla is in general not as strong as Rustchuk, and has in its component parts neither the originality nor unity of design of the fortifications of Adrianople.

As shown in Plate VIII., Schumla is closed in on one side by steep and considerable heights, over which there are but few paths, and on the other side by a still hilly but yet far more practicable district. The fortifications consisted of detached works only; there was no enceinte. On the less hilly side the works were situated along three not very high parallel spurs, separated from one another by brooks. The extensive horseshoe-shaped elevated ground on the other (south-west) side of the town forms in its upper portion a spacious plateau, the outer edge of which was covered with fortifications. All these works were at distances of two to five kilometres

* They numbered 260 pieces, of which 70 were 15c., 12c., 9c., and 8c. breech-loaders. The garrison consisted of 20,000 men. The ammunition and food was sufficient for a regular siege.

† Colonel Ott says, in his account, that obstacles were but little used, but that numerous mines were discovered in all the works he saw, the situation of which he describes as follows: 'Tubes were buried in the glacis at intervals of about 20 metres, terminating at the interior slope, from whence they were to be fired by ordinary fuse. The mines themselves consisted of two shells each, loaded with dynamite, and sunk one to two metres below the surface; they appear to have been intended chiefly to excite alarm.'

apart. They did not exhibit particular strength, nor was their mutual flank defence more than partial.

Owing to the circumstance of the place having no central enceinte, it would have been an easy matter to pierce the fortified girdle line, especially between the works Tyrnow and Sary-Bair, which are about five kilometres apart. The works of Schumla belonged, as to their construction, to several periods and styles. Among them are old forts and new ones, permanent and semi-permanent works. In general they were more spacious and intended for larger garrisons of infantry and artillery than the works of Adrianople and Rustchuk. The ramparts were higher, the ditches were shallower, but provided with flanking defence. The interior of the works appeared spacious, and there were but few traverses.

Amongst the most important of them were:

Ildis Tabia, a large fort situated at the northern end of the plateau. Its position was very favourably chosen, as it commanded the whole of the lower environs of Schumla. The trace was, however, old fashioned, being a crown-work closed at the gorge by an exposed detached wall.

Tscherkes Tabia, a battery for 9 guns, with its gorge closed for infantry defence (Fig. 1, Pl. VIII.). The guns stood on gun-banks, with traverses between them. The front and two side faces were strengthened by a covered way with traverses. In the ditch, close to the entrance, a blindage was built.

Moskow Tabia, a battery for 16 guns, with closed gorge.

Beschtené (Fig. 2, Pl. VIII.), a particularly neatly built permanent work, of forty years ago. In this seven-sided fort is to be found everything which was then thought necessary for a strong work, including a masonry escarp carried up as high as the plane of site, caponiers at the salients, casemates under the ramparts, and hollow traverses on the terre-pleins: finally, there was a covered way with semicircular places of arms. The counterscarp is merely of earth.

Zebek Tabia, a field work in the form of a horseshoe (Fig. 3, Pl. VIII.). The whole terre-plein was armed with guns, every gun having its traverse and separate ramp. In the ditch were two wooden caponiers organised for infantry defence, which could only sweep the ditch very imperfectly, on account of its circular trace. The summit on which the fort lies has a long tongue-like projection on the side of the entrance. In order to neutralise the undefended space resulting therefrom, the Turks made a sort of covered way round this tongue.

Kasanly, a very roomy work having several bastions, but unfinished.

Dym-Tschengel, a pentagonal field redoubt, and Tschengel, a spacious, old-fashioned permanent work (Fig. 4, Pl. VIII.).

Fillibé, a semicircular work, similar to Fort Zebek.

Tyrnow (Fig. 5, Pl. VIII.), a hexagonal redoubt for 16 guns, with three wooden caponiers, a twofold terre-plein, and bridges across the ditch. The revetments consisted of hurdles, gabions, and fascines. In Tyrnow the traverses (Fig. 6, Pl. VIII.) were revetted to their full height with large gabions, $2\frac{1}{2}$ feet in diameter and 9 feet high. To impede escalade the slopes of the escarp and counterscarp were steep.

At the conclusion of his remarks the author expresses his regret that there was no regular siege of the fortresses of Adrianople, Rustchuk, and Schumla, and holds the opinion that the Turks would not have been in a position, in these fortresses, to offer a lengthened resistance; whilst their field fortifications, so admirably and plentifully employed on the European theatre of war, were of great service to them, and cost the Russians, as at Gornyj-Dubnjak, for instance, very dear. The Russians had in the course of this war made less use of field fortifications than the Turks, and blame might appear to be attributable to their engineers on that account. Such accusations could only arise from misunderstanding, for at all periods of the late war, when the Russian engineers were properly handled, their performances were beyond all praise. When, however, as may unfortunately have been the case now and then, the technical troops were employed in a manner unsuited to their nature and duties, it could only be at the expense of those duties and works which technical troops alone can execute. On the arrival of Adjutant-General Todleben with the active army, the possibility of such evils occurring was almost excluded, especially at Plevna. The Russian sappers were from this time exclusively employed in designing and executing the works of the investment round Plevna, which was then begun on a large scale. Thus the 4th sapper battalion had, for instance, in the district between the Tutschenitza ravine and the Roumanian position, partly to execute a length of nearly 15 kilometres of the investment line, and partly to superintend the workmen. In the course of time, during the siege, there were in this district trenches to the extent of about 14 kilometres; 29 batteries for 168 guns, of which 8 were siege batteries or 48 guns, and in addition 8 field works with double and triple lines of defence, roads of communication made in the most rocky ground, with plentiful use of dynamite, to the extent of 6,670 metres; 17 bridges, magazines and depôts for ammunition and other wants of the troops, blindages, and field ovens as required; also, more than 15,000 gabions, 8,000 fascines, and 1,000 hurdles were made.

And all this occurred between the 9th September and 29th November, old style, with a force of at first four, then three, and after the 1st November only one company of sappers.

The following remarks, extracted from the account of Colonel Ott, may here be inserted:

'The Russian infantry were deficient in intrenching tools; to each infantry regiment (3 battalions of 5 companies each) there were 150 shovels, 15 picks, 15 axes, and a certain number of crowbars. The shovels were strong, with straight helves, and carried over the shoulder in a leather case, but they were thrown away by the soldiers as irksome burdens. Skobeleff's brigade were obliged, in order to obtain cover, to work for their lives with bayonets, side arms, field kettle lids, and their very hands, in the hard fights round the Krischin redoubts. The Roumanian infantry were supplied with the light Austrian infantry spade at the rate of 35 per Company, which worked well. The organisation of the engineers was as follows: Chief of the engineer staff, Colonel Berindey. Troops: 1 engineer battalion of six companies, four being sappers and miners, one a railway and telegraph company, and one a pontoon company; total, 900 men. The sapper companies had two tool waggons; the pontoniers had Belgian material and iron pontoons. The sappers and miners were chiefly employed for regular attacks, two companies for mine warfare; in the infantry, pioneer sections were improvised; the artillery built their own batteries.'

J. W. S.

PAPER II.

MACHINE SAPPING.

By Major J. A. Armstrong, R.E.

There is, in all branches of engineering, a continuous tendency, wherever it may be possible, to substitute machinery for hand labour. It seems likely that an increasing use of machinery may at any time be forced on our branch of the service, and in future great sieges machinery be employed to push forward the attack and aid in the defence in a manner unattainable by hand labour alone. If this be a reasonable conjecture, I may urge that an initiative in the matter would properly originate in the Corps of Royal Engineers rather than that the Corps should wait for a lead from civil engineers or American encouragement of invention. Recent developments in the science of electricity now furnish us with a most convenient means of transmitting force from the generator to the machine; there seems every prospect of this source of power-supply being as common in the near future as steam, gas, or water is at present, and it certainly possesses far greater facilities for being brought to, and utilised in, the field; so that I think the time may now be ripe for the Corps to take up this question.

With this view, I desire to lay before the Corps the result of my endeavours to design a machine that should execute or supplement the tedious work of the Sapper. Before venturing to write this note, I should have desired to test my views, and would have done so if the circumstances of my present employment were not prohibitive. I am fully aware of the practical difficulties that lie in the way of getting out a working design on paper, yet as it may be some years before I can get home or have the necessary leisure or opportunity, I now describe the most generally suitable design I have, up to the present, hit upon.

The conditions most necessary appear to be :—

1. The machine must be light enough to be handled and controlled by one or two men.

2. It must be fully protected by the cover it digs for itself.

3. It must throw the soil out well in *advance* to cover itself, and the throw of the soil must be controllable as in hand labour.

4. It should feed itself up to its work.

5. It must be capable of easy deviation from a straight line right or left, work deep or shallow in order to turn obstacles or a corner, or widen out a section.

6. It should be easily arranged to throw the soil to the right or left.

7. Heavy machines should be self-moving backwards as well as forwards.

8. The machine must be capable of easy adaptation to work in various classes of soil with respect to cutting tools and rate of advance.

I have found the third condition the most difficult to meet satisfactorily, and my present invention is based on a rotatory thrower or shoveller, working in a plane inclined at an angle (say 45°) to the horizon (*see* Fig. 1), which throws off the soil excavated as tangents in that plane to the circle described by the thrower; the control of direction, or elevation of the throw, is regulated by the position at which the soil is free to leave the thrower and start along the tangent. The action is somewhat similar to that of a fan reclining at an angle on its side, with the discharge pipe capable of being shifted round the axis to control the direction of the delivery; for very light soils such an ejector might possibly be devised; it is also possible to arrange the thrower vertically and diagonally to the direction of advance, so as to throw in front and cover the machine, but at present I will only describe the inclined thrower and accessories.

Figs. 2, 3, represent a hand machine for small trenches, advanced sap, &c. It is the simplest form, and most suitable for preliminary experiment and description. I will here notice that, since a man can exert about four times the useful effect in turning a winch-handle that he is capable of realising in digging and throwing, there would seem to be a margin in favour of such a machine, after making liberal allowances for machine losses and imperfections. Fig. 3 is a part vertical section through the machine, and Fig. 2 an elevation of the shoveller or thrower; a conical broad-webbed screw breaks up and feeds the soil to the thrower, but its speed of rotation is much less, in this example, one twenty-fourth that of the thrower. A A is the inclined back or body-casting, and carries the hollow pillar DD, in which rotates the screw shaft B, surrounded by the hollow shaft C C, which actuates the thrower-lever K. The winch handle and crank F E, is fixed to the tube C, and actuates the thrower direct, the screw shaft B passes through and is keyed to the gear wheel G; another gear wheel H is fixed round the pillar D, and a pair of pinions I J are keyed to a short spindle running through the crank lever E by a suitable proportion of teeth in the gearing wheels (such as H and I one tooth more than G and J) a slow differential motion is conveyed to the screw shaft. The action of the thrower is shown in Fig. 2. The curved shovellers or throwers L are centred at the extremities of the lever K. A scoop M is formed at the other end by suitable projections and adjustable steel blades. At the lower under side of the throwers is fitted a very stiff adjustable spring, N, or a block. At the back of the main frame A is fitted a stout bar, capable of a limited rotation around the centre by the hand wheel and screw R. This bar carries projecting pins P Q; the first passes through a slot in the frame, the latter outside the frame. These pins or studs are in the plane of the thrower L, and on the base of the spring N, coming into contact with the stud P, the shoveller is thrown outwards until arrested by the second pin Q, when the stuff is ejected at the increased velocity gained by the thrower. The thrower is then drawn down to refill itself and repeat the operation. The hand wheel R regulates the position of the lifting and stop studs P and Q, and the elevation or direction of the throw. The machine is provided with small trucks T (Fig. 3), a long lever U, and cross handle V. For convenience of guiding the machine a guide-wheel W, with clamp X, is fitted on the long lever or pole U. The flat elliptical section of trench formed directly by the machine may be modified by light plough-shares at the bottom corners, and by coulters above. The single-webbed screw is removable, and would be modified to suit the soil. A part of the screw web might be perforated, or wheel-like, to deliver more freely to the throwers. For working under fire the hand action here shown would require modification, the gearing being all placed low down, and be driven by flexible shafting, or any other means found desirable. This small machine is designed to run in easy soil 40 feet an hour at 60 revolutions of the handle per minute, making a trench two feet broad by one-and-a-half deep, and with three to five men in attendance.

Figs. 4, 5, show a larger machine, with 3 or 4-feet face plates, and must be driven by power of some sort. The motor is supposed to be a pair of dynamos driving an endless screw, which gears into a worm wheel of about 70 teeth, driving the throwers direct, and with differential gear, to the screw or excavatoı ; the lettering of the parts is the same as in Figs. 2 and 3. This machine has a triple thrower, and the guide-wheel is fitted with screw action to move the machine in a vertical and horizontal plane.

A 4-feet machine, cutting a trench 4-feet wide by 3-feet deep, running at 2,800 revolutions of the dynamo, 40 revolutions of the thrower, and four revolutions of the screw per minute, would advance two feet per minute, and throw out 24 cubic feet of stuff, making an advance of 40 yards an hour in easy soil. The actual work done is about $\frac{1}{2}$ HP. I will not speculate as to what would be actually required, but cost would be a small object if such a rate of advance and saving of men could be obtained. If some other power were to be employed, I should favour a low pressure in the connecting tubes, and, if possible, use hose in advancing, and this leads me to propose a vacuum motor, or a gas engine; even if the gas had to be made, I think it preferable to making high pressure steam at a distance for our purposes.

Large machines would probably not be manageable by the rear guide-wheel alone, and the screw be inapplicable, both as a feeder and excavator. In Figs. 6, 7, I show another form with driving trucks to carry diagonal slips, spikes, &c., so as to secure a firm bite on the soil, and to support and move the machine. This would also allow of the substitution of blades, picks, drunken-cutters, &c., in place of the screw, when the nature of the soil requires it. Other methods of moving the soil, such as undercutting, crown-cutters, fork-diggers, will suggest themselves, but I expect for service some modification of the screw will on the whole be best.

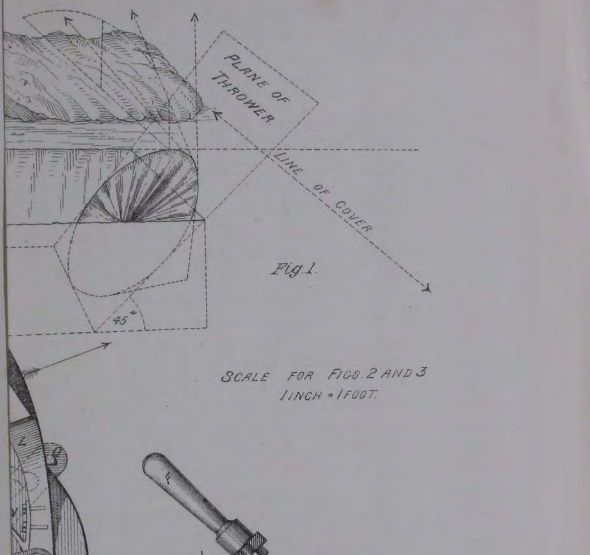
It will be easy if this invention be workable to design machines to complete the trenches or batteries, and thus most materially facilitate the construction of field and siege works.

In connection with this subject I would suggest the use of iron plate revetments as suitable for rapid work (*vide* Plate III.). The principle is simply a pair of flat-buckled, or otherwise stiffened, thin plates; the lower extremities are hinged or jointed to each other, and the lower plate is buried horizontally in the parapet; the face plates are tied back to the buried plate by a tie-rod or stays, with bolts, buttons, &c. There is less material than in a gabion of the same class, far greater hold on the parapet, with smooth surfaces and safety from being burnt in batteries, and it is easily packed, and requires no making up.

J. A. A.

ABBOTTABAD,

June 18th, 1882.


PLANE OF THROWER
LINE OF COVER
45°
Fig.1.
SCALE FOR FIGS. 2 AND 3
1 INCH = 1 FOOT.
Fig.3.
Serg^t Booth R.E. 83.

PAPER III.

A SHORT OUTLINE OF THE IRRIGATION CANALS OF LOWER EGYPT.

By Lieut.-Col. Helsham Jones, of the Royal Engineers.

The object of the following paper is to give a general outline of the canal system of Lower Egypt—if system it can be called.

I am not aware that any treatise exists which gives anything like a complete account of the canals in their relation to one another for the distribution of water, though much information is to be found in the work of Linant de Bellefonds. Indeed it appears that the inquiries of Europeans into the working of Egyptian canals have hitherto been regarded with no little jealousy.

After the occupation of Cairo in September last, as I had been sent to Egypt specially with reference to canals, I was naturally anxious to obtain any information I could on the subject. This I found by no means easy. I was, however, fortunate enough to make the acquaintance of Count Rossetti, a gentleman who is well acquainted with Lower Egypt, and who has projected a scheme for systematising the distribution of water. A main feature of his project is the consolidation of pumping operations. Everyone who has taken any notice of the irrigation in Egypt, must have been struck with the waste of power which evidently goes on in the numberless pumping stations scattered about the country. M. de Rossetti proposes to collect the pumping work into a small number of lifting stations. In the course of working out his project he has had to study the method in which the water is distributed, and it is to him, and to his colleague, M. Barois, that I have to acknowledge my obligations for the materials for the present sketch. The outline given may be of use to any of my brother officers who wish to take advantage of the opportunity afforded by the occupation to study the subject on the spot. Should any be induced to do so, I hope he will give us the advantage of all the information he car obtain.

The maps of Egypt are extremely defective as relates to canals That published by the Intelligence Office for the campaign is mainly copied from the maps of Mahmúd Bey. On it some canals are show by a single blue line, which are really of more importance than other which are shown as much larger. It would be difficult to show completely on such a scale the connections of the various canals, bu where canals actually cross one another on different levels it would b easy to indicate the fact. Perhaps some of our officers may hav opportunities for adding to the information now afforded by the ma in this respect, as well as in others.

I have endeavoured to transliterate the names, so far as I hav been able to obtain their spelling in Arabic characters, in accordanc with the Indian official system. The spelling of the names on mos maps of Egypt is French, and it is somewhat difficult to ascertain i all cases what the native form of a name really is.

December 1882.

CANALS OF LOWER EGYPT.

Lower Egypt divides itself into three fields of irrigation:

1st. The Eastern, which is bounded by the Damietta branch c the Nile, by the desert from Cairo to Kantara, and by the Lak Menzálah.

2nd. The Central, which lies between the Damietta and Rosett branches and the sea, or Lake Búrlos.

3rd. The Western, which lies on the left bank of the Rosett branch, and is bounded by it, the Desert, and Lake Mareotis.

The general slope of the country is in two directions from th apex of the Delta, viz:

From S.E. towards N.W., and from S. to N.

In addition to this, each branch of the Nile has by the continu deposit of silt raised its bed and banks above the surrounding country the cross section from E. to W., which results, is somewhat as shown i the section given on map. The barrage having, owing to defects c design and of construction, failed to answer its purpose, the canal syste of Lower Egypt depends entirely on the old network of canals. Th only office which the barrage serves is to assist in dividing the suppl brought down by the Nile in cold weather between the two branches; and even this it does only imperfectly, because the river is not properly trained, and the supply, instead of impinging fair on the apex of the works, comes in at present (1882) from the left bank, and sets on the Damietta barrage.

The principal canals in the Eastern Irrigation Fields are as follows:

(The Freshwater Canal, or Canal of Ismailia, is omitted. It is the only properly constructed canal in Egypt, but was made to answer a special purpose.)

1st, the Sharkawíyah; 2nd, the Básúsíyah; 3rd, the Bahr Múez; 4th, the Sáhil; 5th, the Búhíyah; 6th, the Umm Salmeh; 7th, the Mansuríyah; 8th, the Sharkawíyah of Damietta.

1st. The Sharkawíyah has its head on the Nile about five miles below Kasr en Nil, and about one mile below the Shúbra head of the Ismailia Canal. There are headworks of masonry. It has a course of about 15 miles to Shibín al Kanátir, where it divides into two principal branches; the one on the right is called the Shibíni, the other the Khalíli. The Shibíni branch passes near Belbeis, and then turns northward, crosses the old Wadi Canal on the level six miles from Zagazig, and has a further course of about 20 miles towards Salihíyah until it is rejoined by the Masraf Abúl Akhdar. The Khalíli takes a nearly northerly course from Shibín towards Mít Bashár, where it joins its surplus waters to those of the Khartaníyah and Filfilah, and is continued under the name of the Masraf Abúl Akhdar, till the Shibíni is joined as above-mentioned.

The Sharkawíyah is not navigable; it has no head lock, and is crossed by low fixed bridges.

2nd. The Básúsíyah has its head, a masonry work, about one mile lower down than the last, and just above the village of Básús. It is not navigable. It has a north-westerly course of eight miles only, and divides into two principal branches, namely, the Khartaníyah and the Filfilah. These two canals flow at no great distance apart, and after a course of about 30 miles their surplus waters reunite east of Minyat al Kamh, whence their combined stream, joining that of the Khalíli, is known as the Masraf Abúl Akhdar, until its junction with the Shibíni, as already stated.

3rd. The Bahr Múez, like all canals having the designation Bahr (sea), is believed to be an ancient branch of the Nile. Its head is on the Nile, about 44 miles below Kasr en Nil, close to the village of Mít Rádi. Passing north of Minyat al Kamh it reaches Zagazig, where it gives water to the old Wadi Canal by a regular masonry head. It has three branches to the left, known as the Katmíyah, the Tahdír, and the Umm-at-Trish canals, and one (besides the Wadi Canal) to the right, called the Messalaníyah.

The Bahr Múez is navigable to Zagazig only. Its main stream pursues a north-westerly course under different names, Sán al Hagir, until it is lost in the swamps bordering on Lake Menzálah.

4th. The Sáhil has its head (masonry) close to that of the Bahr Múez. It keeps, as its name implies, on the high ground close to the Nile for about 18 miles, until it passes Mít Ghamr. Here its surplus water passes to the

(5th) Búhíyah Canal, which has its head about a mile below Ziftch. This canal passes N.E. by Sinbeláwin to Lake Menzálah.

6th. The Umm Salmeh and (7th) the Mansúriyah are both taken out of the Damietta branch, within a mile of the Búhíyah, and flow for 21 to 25 miles independently. South of Mansúrah the second gives part of its remaining water to the first, and forms the Bahr Tanáh, passing the town of Tanáh, whilst the Mansúriyah itself continues under the name of Bahr Saghír to Al Menzálah.

Lastly we have (8th) the Sharkawíyah of Damietta. This canal has its origin about a mile below Mansúrah, and keeps on the *elevated* ground close to the Damietta branch (for which reason it is also known as As Sáhil) until it reaches the town of Damietta. It is in its lower part in a very neglected state.

In the Central Field of Irrigation, comprising the two provinces of Menúfíyah and Gharbíyah, we find the Menúfíyah Canal taken out at the bifurcation of the branches of the Nile between the two barrages, and a number of canals all deriving their supply from the Damietta branch. The principal canals from the Nile are: (1) The Menúfíyah; (2) the Sersáwíyah; (3) the Bajúríyah; (4) the Bahr Shibín; (5) the Tura'-t-al Atfah; (6) the Hadráwíyah; (7) the Sáhil.

The Menúfíyah is taken out by a regular masonry head at the barrage, and if this work had proved successful, would have gone far to supply the whole of the water required for the Central Field. As the work has failed, it is only one among several main canals which draw their supply from the Damietta branch. At about its seventh mile the Menúfíyah throws off a branch to the left called the Nainawíyah Canal,* which crosses the old (now disused) Faraúyah, and is continued along the high level of the bank of the Rosetta branch nearly to En Negeleh, when it 'tails' into the Bajúríyah. At (about) its fourteenth mile the Menúfíyah crosses the old bed of the Faraúyah,

* This canal has no direct head from Nile, as shown in map.

and divides the residue of its water between the Sarsáwíyah and the Bajúríyah.

About one mile below the point where the Menúfíyah crosses the old Faraúyah is the head of the Sarsawíyah, a canal which runs somewhat east of north between the old Faraúyah and the Bajúríyah, which is next to be mentioned, for about 18 miles. It then divides. A branch goes to the right to the Bajuríyah, another to the left runs nearly as far as opposite En Negeleh, when it also tails into the Bajúríyah.

Next is (3rd) the Bajúríyah; it has the head close to that of the last named, from which it diverges somewhat in its early course, but then making more westing, it runs nearly parallel to it. About six miles below Kafr es Zaiyat it divides into the Kedabeh and the Umm Yúsuf canals.

4th. The Bahr Shibín (named from Shibín al Kum) is taken out from the Nile about 20 miles below the barrage, whence it flows about 13 miles, passing Shibín al Kum, till it throws off a large branch to the left called the Betánúníyah (from El Betánún, a village near). This canal passes about 1½ mile west of Tantah, and reaches the lake Búrlos under the name of Bahr Sefeh.

The next important branch of the Bahr Shibín is the Jafaríyah (named from Jafaríyat Bluss, a village close to its head). This canal, after a course of 32 or 33 miles, pours its surplus water into the third large branch of the Bahr Shibín, which is called the Mít Yazíd (from a village near its origin). The Mít Yazíd has a winding course for about 13 miles. At this distance a rectified line is taken out to the right, which has a course of 16 miles, under the name of Bahr an Nizám. It rejoins the Mit Yazíd, and their combined stream is at last lost in the lake Búrlos. About seven miles below the point where it throws off the Mit Yazíd, and not far above Mehallat al Kibír, the Bahr Shibín finally divides into two branches, the right known as Bahr Faráúi Nabruwah, and the left as Bahr al Mehallat. The former goes to the sea at Al Mádíyah, and the latter into Lake Búrlos.

5th. The Túra'-t-al Atfah is taken out of the Damietta branch within a mile of the Bahr Shibín. It has a course of some 35 miles, and tails into the Bahr Shibín just above the head of the Mit Yazíd Canal.

6th. The Hadrawíyah has its head about four miles up the Damietta branch from Benha al Asl. It flows for about 30 miles nearly parallel to the branch of Damietta, and gives its surplus water to the Sáhil Canal of Damietta.

7th. The last main canal in this field is known as the Sáhil of Damietta. This canal is taken out close to the head of the last described, the surplus waters of which it receives below Zifteh. Its course is along high level, close to the Damietta branch, along which it has a course of not much less than 90 miles to the town of Damietta. From the town of Samanhúd downwards this canal now runs in the borrow-pits of the railway to Damietta.

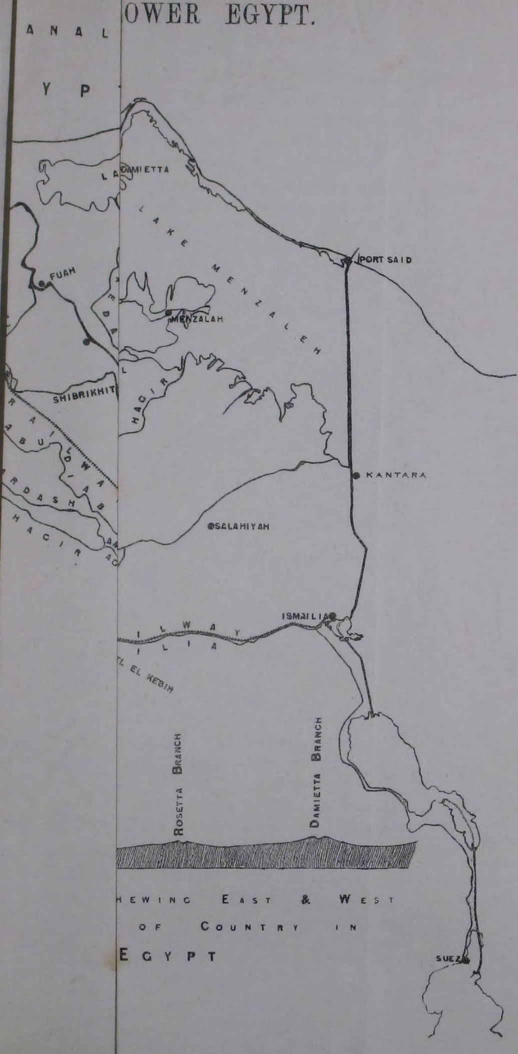
The Western Field

Is far less complicated than the other two. It was intended to be fed by the Bahera Canal, deriving its supply from the Nile on the left of the Barrage de Rosetta; but this canal passes through a desert, and has almost fallen into disuse owing to the difficulties attending the operation of clearing it. The actual supply is mainly drawn from the Rosetta branch, about 30 miles lower down at Al Katátbah, where there are archimedean screw-pumps of very large dimensions for use during low Nile. During high Nile no pumping is required. The canal taken out here, named from the village the Katátbah, is carried close to the Rosetta branch for about 48 miles to below Shibrikhít. It then turns west, passes Damanhúr, and tails into the Mahmúdiah about five miles below this town.

The Katátbah has two principal branches to the west, namely, the Canal Amín Agá (which divides into the Al Hajir and Al Fardásh) and the Abú Diáb.

The first is taken out about a mile above En Negeleh, and the Abú Diáb about three miles lower down. They water the country between the railway line and the desert. Besides this, the borrow-pits on the north side of the railway from the Nile to Damanhúr have been canalised, and the canal so formed serves to irrigate to the north of the line.

Lastly, we have the Mahmúdiah, a canal of great importance, but which can scarcely be looked on as an irrigation canal, since its chief objects are to provide the great city of Alexandria with water, and to connect the navigation of the Nile with that port. In times of high Nile it receives its supply from the Katátbah, but at other times it is fed by the powerful pumping station of Atfeh.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ISMAILIA
EL KEBIR
ROSETTA BRANCH
DAMIETTA BRANCH
HEWING EAST & WEST
OF COUNTRY IN
EGYPT
SUEZ

PAPER IV.

THE SYSTEM OF FIELD TRAINING BEST SUITED TO OUR ARMY.

By the late Lieutenant R. da Costa Porter, R.E.

Introductory Note.

The following essay, on the subject of the System of Field Training best suited to our Army, was written by the late Lieutenant R. da Costa Porter, Royal Engineers, in competition for the medal offered by the Royal United Service Institution in 1882.

The whole of the essay had been prepared in the rough, and the first portion of it had been revised by its author (who was at the time a student at the Staff College) when he received the appointment of second in command of the Pontoon Troop, Royal Engineers, for service in the Egyptian expedition. He took the essay (as it was) with him, intending to complete the revision whilst on board ship, and to send it home for competition from Alexandria. Unfortunately, whilst in the Bay of Biscay, on board the transport 'Oxenholme,' he was struck on the head by a spar which broke loose, and was rendered insensible. He was landed at Malta, where he died a few days afterwards. The manuscript was found amongst his other effects, and is now published precisely as he left it.

I can state, from a careful perusal of the rough copy, that that portion of it which underwent his revision was much altered and improved in consequence. No doubt the remainder would have been presented in a greatly amended form had he lived to complete it. As it is, I feel sure that the essay will be read with interest, not only on account of the sad history attached to it, but also as the product of one who, though young, had already proved himself one of the advanced thinkers of the army.

Whitworth Porter, Major-General,
Late Royal Engineers.

'Cut your coat according to your cloth.'

I do not suppose that anyone will deny, in the abstract, that troops should be well trained, or that, other things being equal, the best trained army will always win. But if we proceed to inquire what form the training should take, we are at once met with a great variety of opinions and views, while, whatever system of training be proposed, a host of difficulties and objections are brought against it. I intend, therefore, in the following paper to discuss, generally, the nature of the training I should like to see carried out in our army, and then endeavour to show how it may best be adapted to the peculiarities of our service.

The duties of the private soldier, the non-commissioned officer, and the officer, are so essentially different that it will be convenient to deal with these three classes separately. I shall commence by pointing out the chief requirements of each.

To begin with the soldier, the following seem the principal points to be kept in view:

(1) He should be physically capable of enduring the fatigues of a campaign, including the covering of long distances in marching order.

(2) He must be well trained in drill, including all fighting formations.

(3) He must be accustomed to work in broken ground, so as to learn the best way of utilising the natural features which present themselves, and to be prepared for the disorder caused by obstacles which may be met.

(4) He should be practised against opposing forces, so as to acquire the habit of noticing the appearance presented by the enemy in his various movements.

(5) He must be practised in outpost duties, when even the private soldier has to use his eyes and brain, to gather information and report intelligibly what he has seen.

(6) He must be thoroughly trained in the use of his weapon, and especially in judging distances in broken country.

(7) He must be inured to the various exigencies of camp life, in order to be able to make the best of unfavourable conditions.

(8) He must be taught the use of the spade and the axe.

(9) Last, but not least, he must be *disciplined* in the fullest meaning of the word.

The non-commissioned officer must be trained in all these, but in more also.

(1) He must be prepared to fulfil the duties of subaltern officers when they have fallen.

(2) He must be trained in the duties of advanced guards and flanking patrols, of which he may have to take command.

(3) He must be capable of commanding small parties on outpost duty.

(4) He should know something of the theoretical side of warfare, to assist him in carrying out the above duties.

(5) He should be capable of reading a map.

The officer, lastly, in addition to a thorough knowledge of drill and the interior economy of his regiment, must know the whole art of tactics. Strategy it will fall to the lot of only a few to require, but all have to fight, to march, to encamp, and to bivouac.

Let us return to the soldier, and inquire at greater length what it is we require of him.

The physical training of the soldier is a matter of great importance, but it is not one which can be dealt with entirely by rule. No amount of exposing a man to hardships in peace time will make him fitter to endure them in time of war. On the contrary, it will tend to sow the seeds of disease which may make him break down just when his services are most required. But though we cannot harden the man by exposure we may certainly make him more capable of bearing fatigue by proper exercise during peace time. The ordinary life of a soldier has too much of an indoor character about it. He has his drills and guards to do, but much of his time is left at his own disposal, and in too many cases it is spent in a way which does little to develop his physical strength. To alter this state of things is the first step necessary.

But it will be found in the sequel that, if the system of training hereafter proposed be adopted, the man will get a very fair amount of exercise in the ordinary course of his drill. For, not only will his drills be longer and more frequent than at present, but they will also often take place at some distance from his barrack square, so that the mere marching to and returning from the manœuvre ground will afford useful exercise to his limbs, as well as instruction in much that is now neglected.

Then there is the gymnasium, of which a more extended use might be made, particularly during the winter months.

But in connection with physical training, there is a point which is, perhaps, of greater importance than one is at first prepared to attribute to it, and that is the necessity for practising men in marching, drilling, and shooting with their full kit on. I fancy few pedestrians will deny that this is a matter in which habit plays a great part. If we would have our men ready at the commencement of a campaign to undertake even average marches, without undue fatigue, we must develop the muscles of the back, which are called into play in carrying the full equipment.

In South Africa, during the Zulu War, the men's packs were almost invariably carried for them and, perhaps, that must always be done in hot climates. But the extra strain thrown upon the transport was very great. In the 'Regulations for Field Forces, South Africa,' the weight of the valise, with field kit, was estimated at 17 lbs. Allowing 800 men as the average strength of a battalion, this would make 13,600 lbs., or six Army Service wagon-loads per battalion. For an army corps, for the Infantry alone, we would thus require 126 wagons for this purpose.

But besides the mere power of moving along a road with their packs on, the men must be able to work across country, surmount obstacles, and use their rifles efficiently. It is often said that soldiers should take off their knapsacks on going into action. No doubt this would add to their physical powers, and, where possible, it should be done. But, on the other hand, we have the oft-quoted dictum of Napoleon, that the knapsack is one of the five things from which the soldier should never be separated. In the German service we find that, as a rule, the pack is not taken off even for an attack, unless the ground be very difficult. Thus, in the attack on the Gifert forest at Woerth, the men only doffed their knapsacks on reaching the foot of the heights (Official Account, Part 1, p. 210). Then again, we are told by Verdy du Vernois (as a caution against doing the same thing again) that a battalion, which had left its packs behind at the assault on the Hubert Farm at Gravelotte, found at the end of the battle that the doctors of a field hospital had rifled them to obtain bandages for the wounded.

Although there may be occasions when a soldier may take off his valise on going into the fighting line, he will more usually have to advance across country, for at least some distance, with it on. The Germans, recognising this fact, have always been careful to insist upon their men wearing the pack as much as possible during drill and manœuvres, and epecially during musketry instruction. They also advocate practising the men in making three or more *consecutive* marches of decent length. This form of route-marching might well be introduced into our service.

Lastly, the men should be exercised in fencing with the bayonet in order to gain dexterity in the use of the weapon, and also to develop their strength.

With regard to drill parades and stereotyped fighting formations, we have two very different schools of thought in our army. First, there is the ordinary regimental idea that smartness and precision on parade are the first and most essential requisites. Secondly, we have the advanced reformers, who appear to think that, because the ordinary drill movements of a battalion are inapplicable to the battle-field, they should therefore be exchanged for something more like what would be required in the face of the enemy. I suppose it is hardly necessary to argue seriously that the truth lies between these two extremes.

Few men who have seen modern warfare will deny the great value of the cohesion and discipline which, as yet, seem only obtainable by steady drill. The Germans even go so far as to maintain a peculiar parade step, difficult to learn, and certainly never to be used in the field, as one of the habitual exercises of their army in peace. Whether this is not carrying the principle too far is open to question, but I certainly was surprised to see in the criticisms on an Aldershot review by a German officer, published in a military paper, that he considered our drill too loose. It may be that German officers are not infallible, and the German system not without its faults, but it must not be forgotten that the army, which is usually held up to us as an example of all that is practical, lays the very greatest stress on the accuracy of parade drills. However much we may wish to give our men the higher training we must not omit steady drill. It is an addition to their present training, not a substitute for it, that I would advocate.

Under the head of drill parades we must include skirmishing and the attack formation. These are very useful and necessary practices, but they are not worth much as a means of discipline, and they certainly do not prepare the men for the exigencies of an actual attack. They are the half-way house between drill and manœuvres, the connecting link between the two great branches of a soldier's training. But, however well a battalion may work in extended order on the parade ground, practise in the field is necessary to carry out the same movements in broken ground. The difficulties of a command become then so much greater that the soldier is inevitably left in some measure to his own resources, and he must be taught to use his head. *Drill* in extended order cannot do this, for it is drill only—it is not training. For the latter we want to accustom the man, as far as possible, to the difficulties he will have to overcome in the real attack, and to teach him to employ his brains to surmount them. Above all, we want to habituate him to the sights and sounds (as far as is practicable in peace time) which will surround him in action, so that when he loses his head, as many men undoubtedly do under fire, he may still instinctively act rightly. It is for this last reason that the constant use of an enemy against whom to manœuvre is most to be desired. Without one all movements must have too much unreality about them to be thoroughly instructive.

But of all situations in which the private soldier is likely to find himself, that of a sentry on outpost duty is the one where his individual qualities will become most apparent. The duty is of the highest importance, and the training required for it by no means easy to impart. An undue use of his rifle as a means of giving the alarm may have the result, not merely of causing an unnecessary disturbance in rear, but, if repeated, of being treated as a cry of 'Wolf.' On the other hand, a carelessness which may allow an enemy to approach unchallenged may lead to the loss of his own life and a gap in the line of sentries.

But do the majority of our privates really understand the meaning and use of countersigns and paroles, and can they be trusted to take the proper steps should a party approaching their post omit to halt when ordered? It is, unfortunately, customary in our service for both officers and men to neglect altogether the sentry's order to halt, while they frequently defer replying at all to a challenge till it has been repeated. In peace time this does not appear to matter, but the habits of peace time are not shaken off in a day, and I have seen the thing done repeatedly on active service.

Then with regard to reporting any occurrence the sentry has noted, how many of our men could give an intelligible account of what they had seen, and how many would forget the direction of their front, or that of their picquets?

Outpost duty, and the individual instruction of the men therein, require more time and care than are usually devoted to them.

With the musketry instruction of our army I think there are two great faults to be found:

(*a*) It is carried out mainly with a view to getting a good figure of merit.

(*b*) It is an annual course, not a continual practice.

The figure of merit was instituted as a *test* of the instruction given; it has become the *object* of that instruction. The colonel, who would have his men trained under some approach to the conditions of active service, must have the mortification of finding his regiment near the bottom of the lists when the results of the annual practice are published. The consequence is that the men are only allowed to shoot under the most favourable conditions, and not, as would be the case on service, in all states of weather and light. Firing with the valise on is also seldom attempted. I should be inclined to say that all practice, save for marksmen's badges, should be done in marching order.

The annual number of rounds fired by our men is very small, and can hardly be deemed sufficient nowadays. It is not any too much for an annual course, and certainly not enough to admit of monthly practice in addition. And yet I cannot but think this latter necessary. It must be remembered that at whatever period of the year we go to war a large proportion of our men, under our present system, will not have fired a shot for many months. What effect that would have upon their shooting may be judged by the improvement the annual course makes in the practice of a company. If more attention were paid to position drill throughout the year some improvement would no doubt be visible. But position drill is wearisome in the extreme, unless it be made the preliminary to actual practice. I would strongly advocate, therefore, the introduction of one day's firing a month.

The use of movable and disappearing targets and the German Zielgewehr for barrack practice would also seem well worthy of consideration. The introduction of field-firing has undoubtedly been a great step in advance, and it is to be hoped it will become more general than at present.

But there is one point connected with fire discipline which seems now to be much neglected. Go to Aldershot on any manœuvre day and watch the conduct of a fire-combat. You will find the men firing away as they like, using *very* independent firing, exhausting their supply of cartridges in a few minutes, seldom looking at their sights, and scarcely ever interfered with by the officers. Can anyone who has seen this believe that a British army corps, had it been at Gravelotte, would have only used an average of twelve rounds a man? At skirmishing drill we do go through a mechanical form of 'odd numbers fire,' 'rear rank fire,' &c., but even this poor pretence of fire-discipline usually vanishes when blank cartridge is employed at a field day. And yet this fire-discipline is a matter of the greatest importance.

Formerly we were told that the volley must now be given up, but latterly a reaction has occurred in its favour. This method of firing undoubtedly gives a great check to a reckless expenditure of ammunition, besides being a very potent weapon, when properly employed, against an enemy. But let anyone in the Long Valley try, after heavy firing has commenced, to get a company to fire a volley, and he will see how much fire-discipline there is among our men. Unless troops are trained to listen to their officer's voice for directions, as to whom they should fire at, when they should fire, and what range they should use, they cannot be said to have real fire-discipline. Above all, it should be thoroughly instilled into the minds of both officers and men that it is not the number of cartridges burnt, but the number of hits made, that really produces the desired effect.

But, though the men must be ready to listen to their officers' voices, it is impossible that the latter should always be ready to give the necessary advice to each man. The soldier must therefore be prepared to use his own judgment when left alone, and above all, he must be capable of judging distances from the appearance of the enemy. For this purpose the more he is practised at judging distances in broken ground, and the more he is exercised in manœuvres against an opposing force, the better. Judging distances, like position drill, should be carried on throughout the year.

Those who remember the first autumn manœuvres at Aldershot must recognise what a change for the better has since then come over our men with regard to knowledge of the ways of camp life. Then, not a thing could be done without the Sapper—kitchens, ovens, latrines, everything seemed new to the regiments. Now when a new camp is formed, it is rare indeed to find a battalion which is not capable of seeing to its own comfort. So great is the improvement that it may scarcely seem necessary to say anything more about it here. There is one point, however, in which, perhaps, a little annual instruction would not be thrown away, and that is the construction of bivouac shelter.

The use of the spade is slowly but surely growing, and it is becoming more an Infantry than an Engineer tool. Much of the work to be done on the field of battle must be performed without the assistance of the Royal Engineers, or it will not be done at all. But this work is usually of a very simple character, and, so far as the execution is concerned, presents little or no difficulty. The planning and tracing alone require any real training, and these must be done by the non-commissioned officers and officers. So long as the men know how to handle a spade and pick, and to make a loophole with a crowbar, it does not seem necessary to spend their time in going through the somewhat elaborate shelter-trench drill. I take it that any officer will be quite capable of stringing out his men along a line of proposed shelter-trenches, once the site has been chosen.

It may be a question, however, whether opportunities should not be given for the construction of shelter pits during field days. The men would thus learn what form of pit suited themselves best, and they would also learn where best to place these pits.

The use of the axe is more important, as it requires greater training than that of the spade. In a country like England no position could, as a rule, be chosen in which there was not a considerable amount of clearing to be done. But if 500 men, untrained to the use of the axe, were turned into a wood for four hours, it is wonderful how little impression they would make upon it. The same number of trained men, in the same time, would make a considerable clearance.

Turning next to the training of the non-commissioned officers, I must first claim from them a thorough knowledge of all that is required from the soldier. They get this schooling, first, while in the ranks; secondly, while superintending the training of the men. But more than this is necessary. If a regiment be hotly engaged it is certain that before long many of the sergeants must be employed in carrying on the duties of the officers who have fallen, and they must be prepared to take their places.

The non-commissioned officer, in fact, occupies a position half-way between that of the soldier and the officer, and his training must partake of the character of both. It certainly is not necessary to instruct him in strategy, or in the higher branches of tactics; but he must at least be prepared to act on his own initiative when detached with a small party of men. Thus the duty of a flanking patrol on the line of march, and of an outpost when the troops are encamped, will demand for their proper execution a certain amount of theoretical, as distinguished from the practical knowledge to be gained in the field. This fact is so well understood in the German service that theoretical indoor instruction is a regular part of the non-commissioned officer's training.

It would be well if this theoretical instruction were given them by their own officers, rather than by the garrison instructor, for thus two great benefits would result. In the first place, the officers would learn more fully what were the weak points of the men under their command; and in the second place, the instruction would take the form of a gradual training and not of a mere 'course of lectures.'

The system too prevalent in our service of teaching various subjects by means of a 'course,' and then leaving the matter alone, seems one which cannot be sufficiently condemned. In itself, a 'course' may be a good commencement to a prolonged training, but it is only a preliminary step to, and not the training itself. It is probably because men feel intuitively the worthlessness of a mere course of lectures, on subjects to which they do not afterwards recur, that so much is said against theoretical as compared with practical training.

Take, as an instance, the classes established at Chatham for the training of Cavalry pioneers. When the course is just finished the men, no doubt, know their work very well. But as the months roll on, without the chance of practising what has been learnt, it must soon get forgotten. Here is an instance which occurred on active service.

A Colonel, commanding a Cavalry regiment, wished to employ a little guncotton. There were two officers in the regiment who had been through a pioneer class, but he asked an Engineer officer to do the work. He said it was two or three years since his officers had been through the Chatham course, and he thought it probable that they had forgotten all about it. The Colonel may have been wrong in this particular case, and his officers may have been quite competent to do the job, but it was natural that he should disbelieve in a system which leaves such matters to the instruction obtained during a few weeks' course without any subsequent practice.

But though theoretical instruction of non-commissioned officers is advocated, the greatest care should be taken to make it as practical as possible. We do not want to develop our sergeants into Jominis. If we try to teach them a little about the theory of tactics we must be careful not to turn our lectures into military history. Perhaps a good rule to follow would be to confine the lectures to explanations over-night of any intended drill or manœuvre, and criticisms, on the evening of the day, on what has been performed. The value of such lectures must of course depend upon the instructor, but a good practical Captain should be able to explain to his men, in a good practical manner, the points he thinks worthy of attention. If, in addition, he has sufficient influence over his men to induce them to take an interest in the subject, and discuss it openly with him, he will probably find that he will gain as much instruction as he imparts.

It is scarcely necessary here to speak of the value of the non-commissioned officer in maintaining discipline, or of the importance of vigilance on the part of the supernumerary rank, from the moment the men are called to attention till the word is given to stand at ease. But there is one point connected with fire-discipline to which attention should be drawn. When the men are extended it is a physical impossibility for the officers to superintend the individual performance of more than a small fraction of their men. The duty must devolve on the leaders of squads, and they must be carefully trained to perform it efficiently. The French, realising the importance of this, have lately issued an order that non-commissioned officers should only have thirty-six rounds each, in order to prevent their neglecting the duty of looking after the men in the more exciting work of firing themselves. The rounds given to them are supposed to be for self-defence only, or, at most, for trial shots to find the range. Beyond this they are not supposed to fire at all.

Let us turn next to the training of officers.

It need hardly be said that the officer should know all that he expects his men to know. But it is open to doubt whether the average English officer does know the details of the drill book and musketry instruction as he should do. It is possible that many officers may argue that an intimate knowledge of the cautions in squad drill would not be worth the time required in getting them up, and that this style of thing may well be left to the drill sergeant and musketry instructor. I am not inclined to lay great stress on this point, but I fancy few Colonels will deny that officers who really pay attention to it are better men for their purposes than those who do not. Certainly, an officer who does know his drill book by heart is better fitted to superintend spring drills than one who does not.

Now, of course, spring drills are not a very high branch of the soldier's art, and the young officer who has just studied the strategy of one of Napoleon's campaigns may find it somewhat of a come-down to have to learn the 'position of the soldier' by heart. But spring drills have their place in the training of the soldier, and a place which, as yet, we cannot supply in any other way. While, therefore, their necessity is admitted they become important as a link in the chain we are forging.

But we will suppose the officer is thoroughly up in all such details, that his knowledge of regimental duties, &c., is perfect, and further, that he has the ordinary theoretical knowledge of tactics and strategy usually obtainable from the received text-books on the subject, and from the instruction to be gained in garrison classes. What more do we want?

Now here I am somewhat in a difficulty. I have admitted that my ideal officer has an intimate acquaintance with the books published by authority for his guidance, and that he has profited to the usual extent by the instruction of the garrison class. If this is not enough we must go behind these authoritative sources of efficiency and knowledge, and point out something fresh. But it would first be as well to show that there is some necessity for doing so.

At the commencement of the war in 1866 it was a very common thing to hear it said that the short service men of the Prussian army, largely mixed as they were with reserves who had been absent from the colours for considerable periods, and themselves without any experience of actual warfare, must fail before the better trained veterans of the Austrian army. The facts completely falsified these opinions, and then every one attributed this result solely and entirely to the deadly effect of the needle-gun, when opposed to the old-fashioned muzzle-loader.

Although it is true that, practically, the needle-gun decided the fate of the war, a close study of the battles of the campaign seems to disclose a fact, the importance of which is perhaps not fully appreciated. Roughly speaking, it is this—that experience of actual warfare had not taught the Austrian regimental officers the necessity that exists in modern warfare for all officers to understand thoroughly the tactical handling, as well as the mere drill, of a battalion. Theoretical training and peace manœuvres, on the other hand, had made the German officers adepts in the art.

Space will not allow of this statement being proved, but the following illustration, drawn from the battle of Nachod, will show what is meant. The quotations are taken from a book called 'Wanderungen über die Gefechtsfelde der preussischen Armeen in Böhmen, 1866,' p. 39, and they form a portion of the criticisms the author makes on the Austrian tactics:

'The quiet, order, and determination with which the Austrian brigade deployed and advanced to the attack should be noticed. All the movements were carried out according to regulation. Divisions, battalions, regiments, stood close to or behind one another as if on parade; the brigade was completely in hand. But if, in spite of this and of the great numerical superiority, the bravely executed attack completely failed, it was on account of the Austrian general system of tactics and training, for which individuals cannot be made answerable. . . .

'What happened? Wholly unpractised in the conduct of a fight adapted to the features of the ground, and to "shooting one's way forward," and for many years drilled only to carry out a badly prepared bayonet attack, there remained nothing but to bring into play this much belauded remedy. The first line was reinforced to a superiority of four or five to one, and went forward without regard to the ground. The attack, however, recoiled powerless before the cool behaviour and the murderous fire of the Prussian battalion. The losses suffered during the retreat were considerable, and then first they sought shelter in the ground. . . .

'The faulty utilisation of the ground for covering advancing columns is very clear, and on the Austrian side no one seems to have noticed it. Thus, Austrian accounts speak of the great watercourse south of Wenzelsberg only as a considerable obstacle. That it certainly must have been under the circumstances, but in no less a degree might it have been utilised as a means of cover. It was well suited to admit the approach under cover of some divisional columns close to the left flank of the Prussian battalion. But of course one must be practised in making use of this and similar features. . . . Certainly they had to pay for serious failings and errors in the just appreciation of the spirit of modern warfare and fighting tactics, and of the peace training of troops to be based thereon.'

Are these criticisms in any way applicable to our own army? Until we have been tried in European warfare it would not be possible to give a decided answer to this question, but the following quotations from a letter of Boguslawski to the *Militär Wochenblatt* will show what the Germans think of our tactics during the Boer War.

He discusses, first, the question of good individual shooting, and draws the conclusion that, important as this factor undoubtedly was, it by no means accounted for the four times repeated defeat of regular troops by untrained farmers.

'The chief and most certain cause of the English defeat lies, to our thinking, very clearly before us. It is the same which caused the heavy losses at the commencement of the Zulu War. First, the undervaluing of the enemy in every way; then the consequent employment of too small a force; in most cases the numerical superiority of the Boers; and lastly, an indifferent tactical conduct of the actions, and an extremely badly considered method of handling the English. . . . .'

Then he proceeds to discuss each action separately, and I have extracted here the chief faults he finds, which seem to bear upon our subject:

'The first encounter which took place was a surprise of the English. The want of precaution can scarcely be excused. . . . . A few flanking patrols would have rendered the sudden appearance of the Boers impossible, and the escort of the convoy would have been in a better condition to receive and fight the enemy. We notice here the same carelessness which is so generally apparent in the non-European wars of the English, and to which Prince Napoleon fell a victim. . . .

'In the second fight at Laing's Nek, 28th January, the Boers were on the defensive, and, therefore, all the more able to make use of their good shooting. According to all accounts the English *seized the bull by the horns.* A frontal attack took place, which failed with very heavy loss, notwithstanding that the English had prepared it by an artillery and rocket fire. There is nothing extraordinary in this. . . .

'The fourth fight, in which General Colley fell, has made the greatest impression, because in this case the Boers stormed the hill seized by the English during the night, and drove them off it with heavy loss, including unwounded prisoners. If one ascribes the defensive power of the Boers to good shooting, one must seek for a new cause here to explain how it was possible for even a three- or four-fold superiority to eject from their position 650 well-trained soldiers, armed with breech-loading rifles. . . . . To me it seems that the complete success of the attack was due chiefly to the circumstance that the position the English took up was not good—that is to say, it was not favourable to the employment of fire.'

I was not engaged in the Transvaal War, and I do not know how far Boguslawski has hit the right nail on the head, but certainly he has pointed out three faults which he supposed were committed, and which might have been eliminated, at least in part, by a careful training of regimental officers. These are—

(1) The conduct of the march of a detachment through a hostile country.

(2) The utilisation of the ground during, and the proper conduct of, an attack.

(3) The placing of men so as to get a good field of fire.

These are all points which require practice for their proper performance, and this practice can undoubtedly be obtained during peace. Important as they are, however, they are by no means the only, or even the most important, points to which regimental officers should turn their attention.

While troops fought in close order, and macœuvered by brigades in line, regimental officers had little need of a knowledge of tactics beyond what was required for the duties of outpost warfare, or of the skirmishing line. Orders came direct from the Brigadier, and if the battalion officers knew their drill they could carry them out without much difficulty. But in the present day this is no longer the case. The Brigadier may order a regiment to attack in a certain direction, or to hold a given portion of ground, but the manœuvres necessary for carrying out these orders must be decided upon on the spot. It is firstly on the Colonels of regiments, and secondly on the leaders of companies, that the duty must devolve of actually ordering the movements of the men.

The necessity for careful individual training of officers and men in fighting tactics, as opposed to mere drill, seems scarcely to have received all the attention it deserves, and yet it is upon this that the battles of the present day are built up. Study any battle of the Franco-German War, and see how it is composed of a mass of details, of the movements and doings of companies and battalions. Compared with a battle like Austerlitz all seems confusion and chance; possibly to some extent it was so as regards the French. On their side officers and men showed gallantry and self-devotion, perhaps as great as on that of the adversaries. As I heard an eye-witness say, 'the red-legs died as freely as any men could,' and yet somehow in all contests, under even circumstances, victory always inclined to the one side. Everyone may not agree with me in thinking this was due almost solely to the better individual training of officers and men in the German service, and yet the more one studies the campaign the more clearly does this fact stand out.

If it be asked where is this training to be got, the answer is in the company and battalion schools. The proportion in which each of these should play its part is a question which must be deferred to a later part of this essay. But here I would wish to point out clearly that it is in the company and battalion schools, and not in big field days and manœuvres, that the real foundation of the training of *both* officers and men must be laid. Not that field days and manœuvres are to be in any way despised. They are a very necessary part of a soldier's training. But in so far as they are a means of tactical training of regimental officers and men, they are so because there the company and battalion schools can be developed under their most difficult aspect.

But in these schools it is not the General and his staff, nor the Garrison Instructor, who can *carry out* the training. It is on the regimental officers that the duty must fall, from the Colonel down to the subaltern; and if they would do it efficiently they must prepare themselves for the work. For this purpose there are three chief means at their disposal:

(1) Drill and manœuvres.
(2) Theoretical study of tactics.
(3) Kriegs-spiel.

Drill may be taken to include the practice of the field exercises, as laid down in the red book; while manœuvres are the application of this drill to broken ground against an opposing force, real or imaginary. I will not discuss here whether the formations laid down are the best that can be devised. They are laid down, and must be adhered to. That regiments should be thoroughly trained in all that is to be found in the drill book must be taken for granted. It is also laid down that drill should be carried out in broken ground. In close formations this is intended merely to accustom the men to drill steadily under difficult circumstances. In extended order it is intended also to teach individual men to make use of cover when skirmishing, and units of men, such as supports and reserves, when executing the attack. But it should be noticed that till we get to Part V. we are dealing only with drill, and when we do reach Part V. we leave the battalion to take care of itself, and deal only with the manœuvres of larger bodies.

Thus in the drill book the battalion has a sealed pattern frontal attack against an immovable enemy laid down for it; but beyond that there is nothing. And yet it is the next step beyond—the application of this drill to the changing phases of an Infantry fight—that the most attention should be paid. Nothing but constant practice of the battalion—whether by itself or in conjunction with the other arms, whether singly or brigaded—in fighting tactics on broken ground, will really train our regiments to the exigencies of the day of combat.

But, in order that this practice may be carried out intelligently and usefully, it is necessary that officers of all ranks should clearly understand the meaning and intention of what they are doing. The word 'theory' is so unpopular in the service that I hardly like to make use of it, but do what one will one must come back to it. It is true that a knowledge of the theory of the fighting tactics of a battalion may, to a great extent, be learnt practically on the exercise ground; but, however learnt, that knowledge is necessary.

But, though I admit most fully the practical training of the exercise ground, I by no means deny the value of the theoretical study for officers as well. If it were necessary to choose between the man who had been well trained in the field and the one who had learnt the subject from books, there can be no doubt but that the former would be the better of the two. But equally there can be little doubt but that the man who had had both forms of training would be better than either.

It is unfortunate that in our language we have no convenient word to express the nature of the study which is alluded to above. We usually call it military history, a very misleading name. Military history really means a narrative of the course of events during a campaign. A knowledge of these may be very interesting, and, in so far as it gives a wider idea of the general aim of military art, it is undoubtedly useful. But at best it leads only to a study of strategy, or of the tactical handling of large bodies of men. Now these are matters which concern rather the Generals and superior staff officers, and not the regimental officers. The latter, if they would derive true value from their study, must endeavour to follow individual battalions and companies throughout the course of an action, to picture to themselves what the Colonel or the Captain saw in front of him, and to realise his reasons for adopting any given formation or line of action.

But to do this requires some considerable practice, and even then it is often difficult to get hold of the necessary details out of any history of a war, however minute. Fortunately there exist critical books on late campaigns, which will train the student to understand and fill up for himself the mere outlined accounts of the histories of battles. It is the study of these I would advocate.

Men sometimes talk as if theoretical tactics were a subject which can only be known by a few learned individuals who lecture about it. Unless they can be learned by those who have to put them in practice they may just as well be left alone. Garrison instructors are not meant merely to train their own successors. Then, again, there are others who seem to think they may be learnt in a course of lectures, like the elements of geology or any other science of facts. In reality I believe no course of lectures on the subject was ever of the slightest use to any man, save as a means of putting him in the right way of studying it afterwards. Theoretical knowledge of this sort must soon evaporate unless constantly renewed by practice and fresh study.

It is not every man that begins to work at the subject who will become a good battalion, or even company, leader; but few will be hurt by such study, while most will be improved by it. Of course there are some men who seem to be gifted with an intuitive genius for troop-leading, and who do not appear to require special training, but such men are extremely rare, and we cannot legislate for their case. The ordinary company officer is no better and no worse than the average man one meets every day, and he cannot expect to be able to do the right thing in the right place, under what are really trying circumstances, unless he will do his best to prepare himself beforehand.

Do what we will I do not see how we are to get on without some theoretical work. At the same time the more we can supplant book-theoretical work by what I must call the practical theoretical work of the battalion school the better. But this latter must itself be based on theory, and the officer who would impart a thorough training to those under his command by means of manœuvres is merely doing, with better appliances, what the garrison instructor tries to do with maps and blackboard.

I have mentioned Kriegs-spiel as one of the means of training. Now if we regard this game as a mere trial of skill between two officers I believe it to be a complete failure. It is not a game, in the ordinary sense of the word, but a study, in which unexpected phases of the combat turn up and impress themselves upon us. First there is the original problem set to the two players, which necessitates their thinking carefully over the particular kind of operation that has to be performed. Then there is the study of the map, the calculation of distances, the rates of marching of the various arms, and the influence of the obstacles to be encountered. Lastly, there is the practice in drawing up the orders necessary to ensure the due execution of the players' designs. All of this is most useful for those engaged, but it is preliminary work, the whole of which might very well be carried out without playing the game at all; and thus, where time is not available for the wearisome hours-long game, the practice might very well stop here.

But if time does admit I certainly think the game should not be omitted. It would be very difficult to get officers to pay sufficiently close attention to the details of the map if the correctness of their calculations and consequent orders were not put to some trial. Without doubt the game does afford in some measure a test for all this. Then, as I have said above, unexpected phases continually arise which would give occasion for reflection, and sometimes teach really valuable lessons.

But with regard to tactics it always seems to me that the attempt to carry them out in detail for large bodies of men is not worth the trouble it occasions, and for anything larger than a brigade we must be content to deal with the necessary movements rather in the lump, and then I do not much believe in the value of the lessons to be learnt.

For small bodies, however, tactical details can very well be worked out on the map, and I fancy that few more instructive practices can be tried than working out problems, similar to those in Hugo Helvig's valuable book, upon the map—one player against the other.

I have laid, perhaps, too great stress on all this book and map work. But if that be the case it is not because the matter is unimportant, but because it bears only indirectly upon the subject of this essay. It may be said that indoor work does not form a portion of 'field training,' and that by 'troops' is intended the army as a whole, and not the officers in particular. I do so because I despair of ever seeing really good field training of our troops until all ranks receive better individual instruction.

Aldershot is perhaps our best school of instruction for the army, but is everything satisfactory there? How often do the battalions there get practised in the species of manœuvering to which I have been alluding? As battalions they seldom leave their parade ground, and 'the tactical handling of battalions in broken ground against a real or supposed enemy' is never practised, save at the larger field days.

Now of these there are two kinds—the 'minor tactics' and the divisional days on the Fox Hills, or wherever it may happen to be. The former do in some measure fulfil the requirements I have been pointing out. But they are made somewhat too formal, and too infrequent. Instead of being looked on as some portion of the brigade programmes for the week, they have to be put in divisional orders. It is the divisional General who undertakes them, and consequently but one at a time can be carried on; while even then they must not be too frequent. As much fuss is made over what should be regarded as the ordinary drill for a couple of regiments with a few guns and troopers, as if it were an army corps being put in motion. The Colonels, acting in command on either side, are made to regard the day as if it were a trial of their own knowledge and skill, instead of an opportunity of affording instruction to their men and officers. If it be necessary to announce these drills in divisional orders, to have several Generals present, and a large staff of umpires employed, the 'minor manœuvres' will always have a show character given to them, in which the wish to gain instruction will be neglected in the endeavour to appear already instructed.

But throughout all Aldershot drills there seems to run an idea of unreality for which it is not very difficult to account. Let us take an ordinary day on the Fox Hills, when a defending force of one brigade is to protect Aldershot from a force of two brigades advancing from Pirbright. Few men can have been at Aldershot long without having fought an action with a general idea of this nature.

The brigades move off to their respective grounds with the very smallest attempts at carrying out the precautionary measures of a march. The artillery cavalry and infantry usually go there independently, and the idea of a combined march with cavalry patrols, a perfectly organised advanced guard of all arms, infantry flanking parties, and so forth, is seldom or never attempted.

The defending force, on coming on the ground, proceeds to take up the position ordered for it. It consists, perhaps, of four regiments, mustering 2,500 rifles, seldom more except during the summer drills; and this force, according to the received ideas of the requirements of actual service, would give a front of 300 yards. But on the Fox Hills the line taken up will usually be from 1 mile to 1½ mile, or, at most, a man and a half a pace. Now, I do not mean to say that in peace manœuvres we should have the 8,000 rifles a mile, which is the authorised strength on active service, for with the small forces employed this would limit the movements too much. But see what a difference it makes in the course of the action. 2,500 men on a front of a mile gives merely a weak first shooting line, without reserves c support for the first line, and without second line or general reserv We may, it is true, form some sort of weak reserve by still furth weakening the shooting line ; but even then there are not enough me to give the defence any manœuvering power. The course of action o the defenders' side will therefore be limited to holding the lin assumed when the enemy attacks it by keeping the men in their fir positions and blazing away. When the enemy closes, the defende feeling his weakness, will most probably give way, and the line wi fall back fighting till the 'cease firing' sounds. Any attempts a counter-strokes, of offensive returns, of manœuvres of any sort, mus be abandoned. The men to carry them out are not there.

Similarly on the attackers' side we find the same unreality apparen The original proximity of the two forces usually prevents any attemp at commencing the action by a reconnaissance made with the ad vanced guard. The whole force is already massed within strikin distance, and it plunges at once in *medias res*. The attacking forc deploys on a front equal to that of the defenders, and proceeds, after very short preliminary artillery fire, to make a frontal attack a along the line. For this purpose alone its strength would usually b far too slight, and as it generally adds a flank attack the strength c the line at any one point is still further reduced. Consequently th attack, like the defence, has little or no power of manœuvering, an the day's proceedings are usually limited to carrying out the forma attack, as practised in the barrack square. It is true that, being i broken ground, some instruction in the use of cover is obtained, bu practice in the real fighting tactics of a battalion is impossible.

However necessary it may be to practise the division in these mor extensive movements we should, at any rate, give opportunities fo exercising them in the denser formations of actual warfare. Mor especially might this be done when, during the summer drills, large bodies of men are accumulated at the camp. But what we usually fin during these summer drills is that advantage is taken of the greate number of men available, not to strengthen the line but to extend i My objection to this very great extension of the line at field days i not based entirely, nor even chiefly, upon the bad idea it is likely t give the troops engaged in it of what they would have to do in rea warfare. Such an objection can be valid to some extent, but it coul be met, partially at least, by the answer that the men actually in th field are supposed to represent a much stronger force—that we ar using, in fact, *skeleton* forces. But it is based on the impossibilit of practising the men in the manœuvres which would be not onl possible but necessary, both during the duration of an attack or a defence.

To take even one of the most simple of the tactical examples in Hugo Helvig, No. 38, I would ask how should we manage at an Aldershot field day to imitate such a manœuvre? The concentration against the enemy's left flank was possible in the first period, merely because, at starting the attack, although two battalions were engaged in it, the firing line was extended only to the amount due to one battalion; the second battalion following behind, as main body, in close order, till required to take its place (still more or less in close order) in the firing line, so as to bring about the crisis of the attack. From what I have seen at Aldershot such a thing is never done. The battalion, with its front of 400 paces, is supposed to be strong enough to carry out the attack to the bitter end; and a second battalion, if available, merely prolongs the line.

But a battalion in our attack formation shows its full extent of front from the very first, and its supports and main body are all required to bring this front up to the required thickness for the ordinary duties of the attack. It has nothing to spare for manœuvering purposes, whether to furnish an overwhelming superiority to a given portion of the line, or to meet a threatened counter-stroke on its flank. If men are withdrawn for either of those purposes, some portion of the fighting line must become too weak. Our battalion, therefore, depends for its manœuvering power on the support of other battalions following it. But, as I have already said, at Aldershot it seems to be considered sufficient to make the attack in a line of battalions in attack formation without second line of reserves. Were it not that the defence is working on the same principles, and has no men available for manœuvering, this error would show itself very plainly even on a field day; but, as it is, it is passed over without discovery, and the opportunity of practising the troops in manœuvering during an attack is lost.

And here I feel much tempted to enter into a discussion on the merits of the German system of company columns, and the consequent employment of large companies. But such questions might be considered beyond the limits of this essay, though they certainly have a very direct bearing on the training it is possible to give to the troops. But I think it is necessary to point out a very vital difference between the German system of extension and our own, which must be understood if we would wish to apply Helvig's examples to our own battalions.

In our attack we begin by deploying 200 men on a front of 400 paces, and we gradually reinforce them up to 800 men, or 4 men per yard. Thus we cannot divert any portion of a battalion, once committed to the attack, from the front line without reducing the thickness of the latter.

The normal German system seems to be to maintain the skirmishing line at its full strength from the very beginning, and to reinforce it by prolonging it to the right and left. Thus, at first, the front shown is only quarter that of the whole battalion, while its length is successively increased until the full extent is occupied. Thus, if at any time a portion of the battalion has to be employed in repelling the flank attack, the front line remains curtailed in length, but is not reduced in resisting power for the front shown. If, again, it be desired to make a converging attack upon the enemy, one or two companies may be moved to a flank for the purpose, and extending there each portion of the line will have the same consistency as if the whole battalion had attacked straight to its front.

Examples of both of these manœuvres may be found in Hugo Helvig repeatedly; but, if we try to work them out with a battalion which has commenced the attack on our system, we shall find, in the first case, that the front line, though only that originally taken up, is dangerously weak; while in the second, we have nearly double the front a battalion is supposed to show.

Our system may have advantages to compensate for these apparent defects, but I point out these differences to prevent misconceptions in studying Hugo Helvig.

[NOTE BY MAJOR-GENERAL PORTER.—There seems something wanting to complete this branch of the essay.]

Having thus dealt with the question of training as it affects the various ranks, the next step is to look at it from a more general point of view, and to see what instruction is to be imparted by the various units of the army. For this purpose I shall divide the subject under the following heads:

(*a*) The recruits' school.
(*b*) The company school.
(*c*) The battalion school.
(*d*) The brigade school.
(*e*) The manœuvre school.

But though I have divided the training into these schools I do not mean that a man is to be passed from one to another after a complete course in any one of them. Such a system might have its advantages, but, as I shall endeavour to show further on, is hardly applicable to our army. When I talk of the company and battalion school I mean the instruction that is to be given by the officer commanding the company or battalion. This instruction must, to a great degree, run on concurrently. Thus one day a man may be at the disposal of this Captain, but the next day the whole battalion may be united under the Colonel, while the third day it may be brigaded.

(*a*) The Recruits' School.

This may be dismissed with comparatively few words. Its object is twofold.

(1) To prepare the new-comer to take his place in the ranks without causing confusion, and to enable him to profit by the instruction given to the older men.

(2) To give him a thorough grounding in the rudiments of drill, so that he may devote his attention thereafter to the higher instruction he will receive.

For these purposes it is necessary that he should have been well trained in Parts I. and II. of the Field Exercises; that he should, by a course of gymnastics, have had his corporal powers thoroughly developed; and that he should have been taught his manual, firing, and bayonet exercise. But whether it is necessary to retain him in the recruits' squad till he has passed his first musketry instruction must depend upon whether we intend in future to limit the musketry instruction of the regiments to an annual course, or not. If we do so limit it he should join the ranks when fit for it by his knowledge of recruits' drill, and pass his musketry course on the next opportunity. If, however, we intend to supplant the present annual course by a monthly practice, he should complete the recruits' course before joining the company. It is this latter plan which I would recommend.

(*b*) The Company School.

Many advocates of the German company school write as if they thought that our companies could receive the same sort of instruction. They talk as if an English Captain might with advantage take his company into broken ground and practise it in field manœuvres on a small scale. But one of our companies, even in a regiment on the strong establishment, will seldom put more than fifty men on parade, and any attempt at tactical movements, with such a body, will degenerate into an absurd caricature of the operations of war. If, therefore, we confine our ideas of the company school to single companies, I think the training to be given must not go beyond the following points:

(1) Steady drill on the barrack square.

be practised at this stage of the instruction: it must be relegated to the brigade school.

But the proper carrying out of the attack by the first line can and must be taught in the battalion school. To do this we require to practice—

(1) The normal attack formation on the parade ground.

(2) The adaptation of this attack to broken ground.

(3) The modification of the attack to suit the actual dispositions of an opposing force, or the supposed movements of a masked or imaginary enemy.

(4) Careful training in fire discipline during the execution of the attack.

(5) Practice of one battalion against another, each commander having complete liberty to act as seems best at the moment

These stages are essentially progressive, and are each of the greatest importance. In the first, the chief object to be aimed at is an orderly carrying out of the various stages of the attack, and the avoidance as far as possible, of the intermixture of units.

In the second, we must add to these an intelligent use of the features of ground; and also, what the limited size of a parade ground prohibits during the first stage, a proper regard to the distances to be preserved by supports and reserves.

The third stage takes away from the more formal character of th training hitherto given, and accustoms both officers and men to th use of manœuvres, which cannot be laid down in the drill book. I this stage the 'halt' should be frequently sounded, the situatio explained to the men, and the reasons given for the movements tha have been, or are about to be, ordered. To render the practice of rea value a sound knowledge of fighting tactics will be required, on th part of both battalion and company leaders.

The fourth stage is one which can be, to a certain extent, combine with the first three; but, as it would require for its complete attain ment a use of blank cartridge, I have thought best to regard it as separate stage, to be taught when the battalion has already becom handy in fighting formations.

The fifth stage can only be accomplished satisfactorily by tw battalions which have been thoroughly trained in the first four. general idea should first be decided on as to the object to be held i view, and the battalions should be as widely separated at starting a they would be in time of war. As a rule, it would be as well to hav the Brigadier-General or other superior officer present, to regulat the movements; but this would not be absolutely essential, provide always that some officer of standing, not necessarily the senior one on parade, is present to undertake the duties of umpire.

But this word 'umpire' may lead to a misconception of what I mean. The practice of one battalion against another is not intended as a competition of skill between the opposing commanders, but as an opportunity for affording instruction to two battalions. An umpire's duties would therefore be confined to preventing the men getting into too great proximity to each other. Where, however, the Brigadier is present, his criticisms on the movements would form the natural termination to the day's proceedings.

For the third and fifth stages I would recommend the use of exercises such as those contained in Hugo Helvig's 'Tactical Examples.' They need not actually be taken from that book, nor in the fifth stage could his examples be strictly adhered to. But in Helvig we can find a guide to the sort of instruction to be given.

The defence may be practised in a similar manner, only in this case the first stage should be omitted. It is scarcely necessary to go through the form of extending men for the defence on the even surface of a parade ground.

But in addition to the attack and defence there are many other points of instruction which come within the scope of the battalion school. Of these the following are the chief:

(1) Taking up a line of outposts. For this purpose broken ground is necessary, and also a general idea to govern the dispositions made.

(2) Route-marching, with all the proper precautions to be taken in traversing a hostile country. I think it is very doubtful whether, in our service, this practice is not made too formal and too little instructive. Perhaps the best method of imparting life to the performance of the duties of the advanced guard and flanking parties would be to start two regiments in opposite directions, so as to ensure their meeting somewhere along the line of march. Where ground is available for a deployment this may be combined with a manœuvre practice, to take place when the regiments have met. Where the ground will not admit of this, the regiments may be started with the idea of one endeavouring to elude the other, by obtaining information of its line of march.

I have tried this latter practice without in any way communicating with the regiment I wished to avoid, merely learning beforehand the hour at which it was going to start and the general direction of its march. Before moving my own men off I merely told them that there was a regiment marching towards us, along the roads somewhere, and that I wanted to conduct my march so as to avoid it, and that for this purpose it was necessary that I should have early and exact information as to its movements. It was wonderful how keen the advanced guards and patrols were to find out what I required.

(3) The formation of bivouacs, including the placing of outposts, and the cooking of dinners in the open.

(*d*) The Brigade School.

The battalion, which has hitherto been working for its own hand, must now be joined to the others of its brigade for training in the higher school of drill and manœuvres. And here, as in the case of the battalion school, the training must be in some degree progressive. It would divide itself, naturally, into the following stages:

(1) Brigade drill in close formation.

(2) The formal attack of a brigade—(*a*) without reference to the ground, (*b*) taking advantage of the natural features that may exist.

(3) Modifications in attack formations to suit the actual dispositions of an attacking force, or the supposed ones of an imaginary enemy.

(4) Manœuvres of one brigade against another, the commanders having complete liberty of action.

Much that has been said of the successive stages of the battalion school is applicable here also, and need not therefore be repeated. But there are certain points, connected with the use of the second line in the attack, to which I wish to draw attention.

In the Field Exercises nothing is said directly about the attack formation of a brigade, but Plates XLI., XLII., and XLIV., give us something to go upon.

In Plate XLI. the fighting line is composed of the three battalions of a brigade side by side, and each battalion, as we are told in paragraph 2, Section 3, Part V., is formed in the same manner as for the attack of a single battalion. There is not, therefore, much to be learnt by practising a brigade in this method of attacking, except accustoming the various portions of a long line to work in concert with each other. Nor can we practise the brigade in the second line formation, for a second line without a first is an absurdity, even for drill purposes. Beyond, therefore, a very occasional deployment of the whole brigade to form the fighting line of an attack, there is no need to practise the first formation shown in the red book.

In Plate XLII. we have each brigade of a division showing two battalions in front, and one as second line. In this case, therefore, our drill will be more instructive, for it will include the handling of the second line. Now the duties of the second line are laid down to be—

(1) To support or prolong the first line.

(2) To confirm its success.

(3) To meet a flank attack.

(4) To protect or cover its retreat if it be forced to retire.

If we consider what these duties mean it will be evident that, from the drill point of view, the second line has a more difficult task than the front line. The latter assumes a certain formation, is directed on a given point, and has to go through a well-known series of movements, which, though liable to modifications owing to the ground, or the enemy's movements, are tolerably well known beforehand. The former, however, at starting, does not know what duty it will be called upon to fulfil, or what formation it will have to assume. And yet it must be prepared to carry out its duties rapidly and with precision.

Under the circumstances it certainly seems to me a very great pity that, in our brigade drills, the second line is omitted altogether, or, at any rate, practically so.

The same reasoning does not apply with equal force to the reserve. If the reserve be not wanted, the battalions composing it waste their time. If it be wanted its duties are very similar to those of the second line. Its omission only affects the training of the General, and, should he require his reserves for any special purpose, he may deviate from the usual course and retain as many men as he wants for that purpose. Judging from the common practice at field days, however, I fancy that, as a rule, Generals will be satisfied at such times with a strong second line.

Another point, on which great stress should be laid in all manœuvre drills, is the necessity for pausing when an attack has succeeded, before pressing further forward. The regiments which have made the attack must be much disordered, and a distanglement of the confused units should at once take place. Preparations must be made for maintaining the ground won against any counter-attacks the enemy may attempt, and time must be required for deciding on the further progress of the action.

When acting on the defensive it may be presumed that the line has been properly organised, weaker possibly than that of the attack, but still on much the same principles. Unfortunately a great difficulty lies in the way of the defence practising the tactics it would have to employ on the day of action. I refer to local counter-strokes, which, in one form or another, must constitute the life and soul of the defence.

These may take the forms of—

(1) An advance of the firing line, reinforced by its supports and reserves, and by the whole or a part of his second line, against a foe already shaken by the fire of the defenders.

(2) A sally against the flank of the attack by troops of the second line.

(3) The advance of the second line directly at the enemy, at the instant of his piercing the front line.

(4) Subsequent attacks upon him, either before or after he has established himself.

Under due supervision of the umpires the last of these may certainly be attempted, but the first three will be dangerous, as likely to lead to a real combat between the opposing forces. I do not see how they can be practised, except against an imaginary or merely masked enemy.

The larger counter-strokes, or definite assumption of the offensive by some portion of the defensive line, aided by the reserve, do not however present the same difficulty.

(*e*) The Manœuvre School.

In this school we have to treat of the training of the various arms together, constituting the highest branch of tactics. In it are included—

(1) Manœuvres between small mixed detachments of all arms.

(2) Manœuvres between larger bodies, more or less approximating to the composition of a division or an army corps.

(3) Autumn manœuvres, or continuous manœuvres, drill including instruction in camp life.

Much that has been said about the practising of one battalion against another is applicable to the first of these. Manœuvres of this nature are certainly not intended as show days, but as opportunities for very valuable instruction. I think it would be as well if they were divided into two classes: (*a*) those in which the opposing forces carried out certain movements prescribed for them; (*b*) those in which the commanders have complete liberty of action. In the first place the General, or whoever has to draw up the scheme of the day's work, should begin by setting a general idea for the operations, and then work out the simultaneous positions the troops would occupy at every stage of the attack and defence. Here, as in the case of the battalion drill of a similar nature, there should be no hurry about the performance of the task. The 'halt' should be sounded from time to time, mistakes corrected, and the object of the various movements explained.

Even when the commanders are left to their own devices, the officer superintending the operations should cause the 'halt' to be sounded occasionally, and, after inspecting the position of the contending sides, he should find out from the commanders their intentions and reasons for acting as they have done. In this way he will find it more easy to draw up a satisfactory criticism on the day's proceedings.

The value of the larger field days, as a means of accustoming the various arms to work together, is very apparent. To artillery and cavalry they afford opportunities of learning how to co-operate with the infantry, such as they can hardly obtain in any other way. To officers, too, of all ranks, the instruction to be obtained is very valuable. For the men of the infantry, however, these days are hardly more useful than an ordinary infantry brigade day. Still they can, at all events, be made as useful as these latter are.

Beyond advocating greater depth and less width in the formation of the contending lines, and a better superintendence of the fire discipline than is now usually to be observed, I do not see that much need be said about these field days.

With regard to autumn manœuvres, however, there are one or two points on which I should like to touch.

The advantages obtained by them are the following:

(1) Practice in camp life and its exigencies. This of course might be obtained at any time, with very slight expense, at most of our stations, and the habit of placing men under canvas might well be more often resorted to than is now the case.

(2) Greater facilities for carrying out a field day than can be obtained when both sides move out from the same camp.

(3) The possibility, unfortunately too rarely taken advantage of, of carrying out a continuous series of operations.

(4) Better practice in the warfare of outposts. It may be a question worth considering whether, in connection with this, it might not be possible to introduce a little more night work, alarms and even partial attacks, and so forth.

It is some years since I have had an opportunity of taking part in the summer drills at Aldershot, but the impression I took away with me from those which I did see, and they were several successive ones, was that much time and opportunity for instruction is lost while the men are under canvas. We often hear Colonels lamenting over the few opportunities given them of having their whole regiment on parade, and how fatigues, duties, &c., reduce the parade strength till the battalion looks more like a company than anything else. But, when in camp during manœuvre, this is no longer the case. The regiments are as strong as it is possible to make them, and all around is the ground best suited for working men over broken ground. A regiment should be taught to look upon the few weeks it gets in camp, during the summer drills, as a valuable opportunity occurring but too seldom, and of which the very most must be made. And yet we find that the number of hours' work done a day is usually kept as low as possible.

[Note by Major-General Porter.—I think something was intended to have been added here.]

Application to our Army.

Hitherto I have been dealing with the various details of training which it seems proper for our army to undergo. I propose now to attempt to reduce this training to system, and show how it may be adapted to the service.

I start with the assumption that the fact of the present subject of this essay has been decided upon, because there is a generally received impression that the actual system of training in our army needs improvement, if we would place it on a level with those of foreign Powers. That this is the case is due to various causes, some of which are inherent in our method of recruiting, and could not be eradicated without organic changes of a nature not to be entered upon here. At best we cannot hope to arrive at the theoretically perfect systems of foreign nations; still I believe we may approach nearer to them than we yet have done. My object will be to endeavour to show how we may, without alteration in the fundamental principles upon which our army is raised, introduce some of the more valuable portions of the continental system of training.

But, before starting, it is necessary to dispose of one difficulty which must be present in the minds of all. The soldier, at the present time, receives a certain amount of training, and that training, if not theoretically the very best that can be given, is at any rate about as good as can reasonably be expected from the amount of time devoted to it. Every system of training that can be devised must commence by demanding greater exertions from both officers and men than they at present are called upon to make. But to this it is usually objected that half the charm of a military life, for the class from whom the greater part of our recruits is drawn, lies in its comparative indolence in time of peace. Were we to work our men in any degree like the

Germans do theirs we should find our recruiting sources dried up, and the army unable to maintain itself with short service at its present strength.

Now to a certain extent this difficulty does occur, as I am afraid everyone must admit, and it is a difficulty inherent in our system of voluntary recruiting. But I doubt whether it is of so much importance as is usually attributed to it. A very large portion of our recruits come forward with the vaguest ideas of what is before them, and are prepared for much harder work than actually falls to their lot. Another fraction are driven by necessity into the ranks. In both of these cases additional time given to training would have little or no effect upon recruiting.

But there is undoubtedly a large class of recruits who deliberately choose the red coat because they hope to have an easy time in the army. If it were once known that the soldier was expected to work for his living, as hard as he would have to do in civil life, these men would not take the shilling. But as it is, these are usually the worst class of recruits we get, and it certainly does not seem logical to abstain from properly training the army in order to pander to the idleness of the more worthless portion of it. If these men decline to enlist we must endeavour to obtain more of the other categories. It may be that this will necessitate higher expenditure, but that cannot be helped. We prefer in England to have voluntary enlistment, but if we would have our voluntary army as good, man for man, as the conscript armies of foreign Powers, we must be prepared to pay whatever we may find to be the market price of the article we require. If we are not so prepared we must put on one side all ideas of higher training, and be content to muddle on as we have hitherto done.

Then, again, with regard to the officers, this higher training will require a greater self-devotion to their work than has hitherto been generally the case. With some this might not be popular, and in practice, no doubt, there would be a good deal of grumbling. But I fancy that there would not be much difficulty in getting whatever we want done, even though it might result in some slight falling-off in the present enormous competition for Sandhurst. A few months ago, the present Adjutant-General, in an article in the 'Nineteenth Century,' accused the British officer, as a rule, of caring little for the hard work of his profession. He pointed out that the leave taken annually by our officers was far longer than that allowed in foreign armies, while the number of hours' work a week was far less. More work and less play is the gist of this part of his article.

This article was certainly not popular in the ante-rooms of the army. With some the idea that the British officer should drudge at his profession, like the German, was scouted as an impossibility. It was pointed out that the conditions of service in the two armies were very different. The German, by becoming an officer, escapes service in the ranks, and exchanges an unpleasant form of duty for one which is less distasteful. The whole nation belonging practically to the army, a military spirit pervades every member of it, and the officer receives a social standing from his commission which is not gained by him in England. With us the majority of officers come from a rank of life which is at least as high in the social scale as that to which his position in the army would entitle him. Then with regard to pay, although in our service it is somewhat higher than in the German, yet compared to the scale of living in the two countries it is much less. In Germany the officer looks to his pay for his income; in England this is very far from being the case. Lastly, if the British officer is to pass all his time on the parade ground, or in the study, he must lose many of the qualities which we have hitherto looked upon as being most valuable.

But this line of reasoning was by no means general. A very large portion of the army argued that they were ready and willing to undertake the heavier work and new duties hinted at in Sir Garnet Wolseley's article. But they pointed out that, under our present system, it was more or less impossible. One of the chief of these duties is the training of the large number of recruits which, under our short service system, annually join each regiment. Now in Germany these recruits all arrive in one batch on a certain day, and the company officers can set to work to train them systematically in large bodies, and in a progressive manner. With us, however, they arrive in driblets throughout the year, and we are practically obliged to fall back upon the adjutant, the sergeant-major, and the orderly officer, with their staff of drill-sergeants. The true company system of the German army cannot be carried out.

Another essential point of difference, which has a great effect upon the possibility of getting our officers to supersede the drill-sergeant, is the system of making the home battalions supply large annual drafts for the foreign army. This is not the case in the German service, where the recruit, on joining his company, comes for three years under the hands of the same officers, who are thus able to see the gradual effect of their own training, and do not have to suffer the disheartening influence of losing their men just as they are beginning to become efficient.

But, admitting the truth of a great deal of this, I do not think we need despair of introducing a new spirit of work into our service. The arguments of those who say they are willing to work, but find it impossible under our system, do not seem applicable to any part of the soldier's training save that of the recruit, and for this I think we should make special arrangements. But to those who say that we cannot expect the British officer to work like his German comrade we must find a different answer. No doubt, if more work and less play is to become the rule in our army, we shall lose many men who are good sportsmen and thorough gentlemen, and, according to the ideas hitherto in vogue, good officers. Their loss will be a very real one; but will it not be compensated for in other ways?

There are no reasons why a man who is prepared to work should not be as good a gentleman as the one who prefers play; and as for sportmanship, we have only to look around us to see that many of the hardest-working officers in the army are as good riders, and as fond of bodily activity, as any in the service. There is, however, one class of officer of whom we might very well be rid, namely, the ante-room officer, who passes his time in an arm-chair, whose sporting proclivities are confined to studying the odds or a visit to a racecourse, and whose exercise is limited to a stroll in the 'High' or down 'Fore Street.' This class may not be a numerous one, but it exists, and I fancy it is this one which would be most touched up by an increase of work.

But whatever the result on officers or men, an improvement in the training of the army must mean more work, and we must face the alternatives of remaining as we are, or of spending more time and energy over our drills and manœuvres. But if we expect more work from our officers we must endeavour to hold out to them more inducement to work, and that inducement might easily be made to take the form of responsibility for the result of their labour, and a consequent effect upon their promotion.

By this I do not mean a very thorough system of selection, but rather a moderate one of rejection. The occasional compulsory retirement of an officer who will not do his duty thoroughly would be an excellent spur to the zeal of the remainder, and would, to a certain extent, accelerate their promotion. Now that reports are no longer to be confidential, colonels will not feel that they are hitting a man unfairly if they report badly of him, and there will no longer be any excuse for glossing over the shortcomings of careless or ignorant officers.

Presuming that by some means we shall be able to extract a great amount of work from all ranks, let us next see how far our present organisation would allow our training to take the form of an annual progressive course.

I will suppose that the German system is well known to all who may read this essay; if it be not, I would recommend a study of Sir Lumley Graham's very valuable paper on the subject, which appeared in Nos. 109 and 111 of the Journal of the Royal United Service Institution. This system I will take as the model at which I am aiming, of course with the necessary modifications to suit it to the special conditions of our service.

The two most important points of that training appear to be—

(1) That each year the whole of the regiments are carried through a progressive course of instruction, which, starting at spring drills, culminates in divisional or army corps manœuvres.

(2) That the men are trained at each successive stage by the officers commanding the unit for which that stage is intended, while, before passing to the next, they are inspected by the officer under whose command they are about to pass; thus bringing home to each officer his responsibility for the men under his command.

At first sight it would not appear very difficult to introduce these two principles into our service; and, as a matter of fact, we do now attempt, at Aldershot at least, to work as far as possible in this manner. But even before we go into the details of the system, many of which are of the highest importance, and most of which it would be most difficult to adopt, we find ourselves confronted with very great obstacles. To show what I mean it will be necessary to enter into the composition of the battalions at home, which are on the weak establishment. Out of a total of 71 battalions, 43, or considerably more than half, have an establishment of only 480 rank and file, while 8 more are but 500 strong. The total strength of a territorial regiment, of which the home battalion is on the former establishment, and the sister battalion is in India, officers omitted, is as follows:

Home Battalion—Non-commissioned officers	50
Drummers	16
Rank and file	480
Depôt—Rank and file	50
Non-commissioned officers	12
Total at home	608
Indian battalion—Non-commissioned officers	42
Rank and file	820
Drummers	16
Total Indian battery	878
Add men at home	608
Total	1,486

As, according to the organisation scheme of this year, no man is to embark for India under one year's service, the whole of the men, belonging to the two battalions, of less service than this amount, must be included in the 608 men of the home battalion and the depôt. Let us see how many they amount to.

Allowing one-seventh of the home strength and one-eighth of the foreign strength for the time-expired men due to one year, and 6·4 per cent. for the home battalion and 60 per battalion for that in India, for waste (which figures are taken from the Report of Lord Sandhurst's Committee), we find that the following recruits must pass annually into the home battalion:

One-seventh of home strength	=	87
6·4 per cent.	=	39
One-eighth of foreign strength	=	109
60 per battalion	=	60
Total	=	295

Of these recruits, at any given moment, 50 are on the strength of the depôt, and 245 on that of the home battalion.

Thus, in a battalion of 480 rank and file, 245 are under one year's service, leaving only 235 who are above that length of service.

Now, if we suppose that the regular course of instruction is to commence directly after the last draft has left for India, say on April 1st, and to continue till the next trooping season, say the middle or end of September, we shall have at the commencement of the season our 235 men of more than one year's standing, and to these might be added one-half of the recruits, who would have more than six months' service, which would give a strength of 377 men for regimental parades. To these might be added the recruits due to the half-year of the course, who could be placed in the ranks as they successively arrived at the end of their first six months' service. This would give us 147 men more. But it must be remembered that, though these men would gradually swell the numbers, there would be a corresponding depletion going on from time-expired men and waste of the home battalion, which would result in a loss of 63 men in the corresponding period. The net result would be, therefore, that we should commence the drill season with 377 men and end it with 461 men. Further, it must be remembered that those men who join during the course will only receive a partial training, while those who leave during the same period will also lose the benefit of that progressive schooling of which so much is now thought. In fact, in any one year only 314 men in the battalion would receive a complete training.

But even this is taking too sanguine a view of the case. In the first place it has been assumed that the recruiting could be so arranged that the regiment will be at its full strength directly the Indian draft has left; but, in order to do so, it must have been above its strength before, which will hardly, I fear, be the case as a rule. In fact, the real way of looking at it will be that the day after the departure of its Indian relief the regiment will be by that amount under its strength, and that it will have to replace these men, who are all, be it observed, of more than one year's service, by new recruits to be obtained as rapidly as may be. The available men of more than six months' service will, therefore, instead of varying between 377 and 461, really vary between 293 and 377; so that, allowing for men who leave during the course, the total number who will be present during the whole training will be only 230.

If we further take into account the unavoidable absentees from parade, the guards and fatigues, both regimental and garrison, prisoners, deserters, sick men, and those specially employed, I think I shall be rather over than below the mark if I say that 200, at the commencement, and 300, at the close, of the drill season will be the maximum ever present on parade, and 175 and 275 the corresponding averages.

While the battalion is undergoing the company school these numbers will admit of the formation of two to four companies. But if we take an eight-company battalion and make it up into two companies for drill purposes, or even four, it is evident that the training of companies by their own officers becomes impossible. Thus the second of the two main principles quoted above has at once to be neglected.

But the matter is still worse when we come to the battalion school; for the numbers are too small to admit of any satisfactory battalion manœuvres. It is true that a certain amount of battalion drill may be attempted, but the higher training of manœuvres becomes impossible.

This impossibility becomes almost an absurdity when we attempt brigade or divisional manœuvres with such small units; and thus the progressive training, which is the first of the two main principles quoted above, has also to be broken through.

It seems to me, therefore, that the progressive training of the fifty-one battalions on the weak establishments is a practical impossibility, though it is no doubt more or less applicable to the remaining twenty battalions. Nor does there seem much reason why it should be attempted for these weak battalions if we accept the apparently authorised explanation of their existence, This explanation seems to be somewhat as follows. We had and still have 141 battalions to deal with, of which 71 are at home and 70 in India and the Colonies. The total strength of the 71 battalions (exclusive of the permanent staff of the depôts) amounted to about 42,000 men, or an average of 600 men per battalion. But of these it was found that not more than from 400 to 450 could be counted upon as fit to go abroad or on active service, even before the present system of furnishing reinforcements for a foreign battalion through the home one was introduced. Hence, whenever a regiment was ordered to embark suddenly, it became necessary to make it up to the proper strength by volunteering from battalions whose services were not immediately required. The evils of this system were a constant source of complaint. To remove this defect it was decided that a certain number of regiments should be kept up at what was practically war strength, and thus we are now to have twelve battalions of 950 men and four of 850. But as it was not intended to increase the total number of men with the colours, the other regiments had in consequence to be reduced. Hence our fifty-one very weak battalions.

But so long as the depôts could supply the recruits required for the battalions abroad, these fifty-one battalions, though weak, were in a much better condition than now; the proportion of men of over one year's service being about double what it now is. Since, however, it was decided that men should not be sent abroad under one year's service, it became necessary to treat the home battalion as a depôt for the foreign one, which, however, it must be owned, it had been to a great extent before. Unless the total number of men at home were to be increased all the men of one year's service must be taken from the battalion at home. I have already shown that 300 recruits a year are required for the two battalions, or an average of 25 a month. As the depôt only consists of 50 men it will not usually have men of more than two or three months' service, and hence all men of one year's service must have been counted on the strength of the home battalion for nine months at least. Of course the depôt might be increased in size, but, unless the total strength of the home army were increased in like proportion, this could only be done by still further weakening the already attenuated home battalions.

The opponents of the system point out that the result is to render these weak home battalions practically useless. The official answer appears to be that they are not useless: they are depôts and training schools by which our Indian and Colonial army is maintained; while for active service abroad we have, in the first instance, sufficient material for one army corps kept in a state of readiness, and, by calling in the reserves, we can raise as many more of the weak battalions as we like to a war establishment.

Now, if we accept this idea loyally, it will follow that we need not regard these fifty-one battalions as anything more than training schools for individuals, nor count upon them as units which would have to take their place in the line in case of war. This can easily be shown.

I have already said that at any given moment the number of men of over six months' service in each battalion will vary from 293 to 377. Let us take the higher figure and deduct from it, what would certainly be a minimum, 77 men for absentees, prisoners, men unfit to take the field, &c. This will leave 300 men available to form a part of the regiment when mobilised. But a regiment on a war footing requires the following men :

Corporals	41
Pioneers	13
Band	20
Privates	904
Drivers	22
Total	1,000

Thus 700 new men will have to be brought in to raise our battalion to its proper war strength. The new body thus found is the old one in name only, and no amount of careful training of the latter will make the former a trustworthy machine wherewith to work.

We see, therefore, that the recognised idea of these battalions, as mere training schools for recruits, and as depôts for the sister battalions abroad, is the correct one, and nothing will be gained by trying to treat them as real regiments. In them the training of the recruits will be the chief work to be done, and the higher schools may be comparatively neglected. The recruits will arrive at the rate of twenty-five, or about half the strength of a company, a month ; and, in order to enable the officers to look after their own recruits, I would suggest that all those coming in during a given month should be posted to one company, each company in turn being told off to receive the new-comers.

As the companies are very weak I would suggest that company drill should be habitually carried on in double companies, though the individual instruction of men and non-commissioned officers might still be done in their own companies and by their own officers.

The battalion school can only partially be carried out, and should be confined almost entirely to the parade ground. Similarly the brigade drills would be limited chiefly to parade movements.

Lastly, none of these weak battalions should ever take part in manœuvres on a large scale.

But, with these exceptions, I think we should endeavour to systematise the instruction given as far as possible in accordance with the plan I shall propose for the remainder of the army.

In thus boldly saying that three-fourths of our regiments are to take but a very limited part in the system of instruction that I am advocating, I feel that I am exposing myself to the criticism that my system is not that best fitted for our army. But, in the first place, I would point out that while our regiments are so very differently organised from each other as they are now to be, it would be pedantic to endeavour to make one system fit all. In the second place, we have it on authority that the remaining twenty battalions really form our whole field army. And in the third place, I desire to put forward a project for rearranging our men so as to be able to give the full training to a maximum number of battalions; as, however, I fear that that matter hardly falls within the scope of this essay, I have relegated it to an Appendix.

It is as yet difficult to foretell exactly how our new system will work with regard to the battalions on the larger establishments. It is certain, however, that the proportion of men of under one year's service will not be more than one-third of the entire regiment, while the number of men who will remain in it after being trained will be very great. The officers will thus have an inducement to look after the instruction of their men, which does not exist in the weak battalions; while in each company there will be a strong nucleus of men who have already had at least one year's training, and who will remain during the whole of the year's course. In these regiments we may therefore hope to be able to systematise the training, at least to some extent. But even here there must be a great difference, at all events in the company school, between our service and the German.

In Germany the whole of the recruits arrive on a given day, and for some weeks the whole energies of the officers are devoted to preparing them to take their place in the ranks. The training of the rest of the company during this period is confined to some of the minor details of a soldier's education; the real company school has not yet commenced. It is not until the recruits are ready that the training of the company is taken in hand. The great importance attached to this company training depends in some measure upon the fact that, in the German army, the company is the true tactical unit. The battalion, on the field of battle, is as much composed of separate companies as the brigade is of separate battalions. Each company forms its own supports and reserves, and, as far as is possible, is kept distinct from the remainder of the regiment. It thus employs in action the drill it has been taught by its own company officers, and it fights under those officers.

With us this is quite different. We cannot tell off a certain portion of the year for the training of recruits, for they drop in by twos and threes throughout the year. If, therefore, the recruits are to be trained by the company officers, they will not be able to devote their entire energies to the annual course of their companies.

Nor is the company our tactical unit. If we take the normal attack formation of the drill book we find that the company does not supply its own supports and reserves. It is, rather, all extended at once, or all in support, or all in reserve. Where the supports join the fighting line two companies are doubled up together; at the close of the attack four companies are intermixed. The men are no longer fighting as companies under their own officers, but as an integral portion of a deployed battalion. This fact alone must detract from the extreme value placed by German officers on the company school.

But, in addition to this, the attack, as practised by a company, cannot resemble the functions it will have to undertake when forming part of a battalion. When by itself it must form its own support and reserves, and then the front shown, already smaller than in war time, owing to peace establishments, must be further curtailed. The difficulties of command are lessened, and the men are accustomed to be looked after by their officers in a way which is impracticable when the full front of 200 paces is taken up. The consequence is that both men and officers find that company drill is but a partial training for battalion drill.

Nor can the difficulty be got over by the habitual use of double companies. In the first place, the double company means that the men of the company under the junior captain have two masters, and the officer who commands them under fire is not the same as he to whom they look for guidance at other times. The German idea of the 'Father of the Company' must thus be given up. In the second place, the double company, with our system of drill, only carries us one step further in the attack. We have now a fighting line and support, but we still have no reserve, and again there must be a difference between double company and battalion drill.

This last difficulty might of course be removed by introducing the German system of the attack. We should then, on commencing the attack, deploy one half company of each double company, but on a front of 100 instead of 200 paces; the other half company would form the support, and the second company the reserve. As a rule, the extension would be commenced by two double companies only, the remainder prolonging the line to either flank, as required.

But if, in order to preserve the value of the company school, we were to introduce this formation, it would certainly seem wiser to accept the situation and make our double companies permanent. As, however, there appears little likelihood of this being done, it would be better to acknowledge that, with us, the company school is not the really important one, and that the soldier's training must be completed in the battalion school.

[NOTE BY MAJOR-GENERAL PORTER.—The manuscript finishes at this point. No doubt, had my son lived to complete the revision, he would have here introduced a few suitable paragraphs to close the subject.]

APPENDIX.

According to the 'Revised Memorandum,' in which were embodied the main features of Mr. Childers's scheme, the British army in England was to consist of the following battalions:

43 of 480
8 of 500
4 of 650
4 of 850
12 of 950, these latter belonging to 1st Army Corps.

NOTE.—The remaining nine battalions required for the 1st Army Corps are to be obtained from the Mediterranean garrisons and the Guards.

If we examine the composition of the 51 battalions of 480 and 500 men we shall arrive at rather curious results. In the first place, no man is to be sent to India who is under one year's service. Consequently all drafts of men for India must be taken from the sister battalion at home. The Indian battalion is 820 strong, and the men are enlisted for seven years, with the possibility of an extension to eight years. Let us suppose that every man serves his eight years, then the Indian battalion will require annually $\frac{820}{8}$ men to replace time-expired men. But, according to Lord Airey's Committee, there is a further average waste of sixty men per battalion per year in India, which must be made good.

Then the home battalion has a strength of 500 men enlisted for seven years, and will require on the average $\frac{500}{7}$ men to replace time-expired men, and, according to the same commission, the waste at home is 124 per 1,000, or 62 per battalion of 500.

Thus the home regiment must annually be recruited by

$$\frac{820}{8}+60+\frac{500}{7}+62 = 296 \text{ men.}$$

But the strength 500 includes all ranks—officers, orderly-room clerks, artificers, and so forth. Even if we count in all these, except the officers, we find that in each regiment there are only

$500-27-296$ men of more than one year's service.
$= 187$ " "

When we consider that this number must include the whole of the staff of the regiment, and most likely would include the whole of the officers' servants—if we further make allowances for fatigues, prisoners, sick men, and guards, it is evident that very few men in the regiment, who have joined after the course has begun in one year, will remain with it to obtain a regular training the next year.

Further, if we endeavour to estimate the number of men it should be possible to assemble at any time for battalion drill, the result is not encouraging. Including his recruit's course of musketry, six months is the shortest time before the new-comer can be counted upon as forming a part of the regiment. Thus, at all times, the regiment will be 150 under its nominal strength. After making allowances for officers and the regimental staff, we find, therefore, that 300 is the very largest number of men left. From this number must be deducted prisoners, men in hospital, on guard, or on fatigue, as well as the officers' servants. These would of course vary in number, but I doubt whether they would ever be reduced materially below 100, and usually would be nearer 150. We have, therefore, left as the parade strength of bayonets from 150 to 200. Such a number can hardly carry out battalion manœuvres, though it may make some pretence of battalion drill.

So far, therefore, as the men are concerned, the higher training of the battalion will become impossible. But even if it were possible it may be doubted whether it would be of any value. On mobilisation the only men who could be retained in the regiment would be so many of the 300 above mentioned as could pass the doctor. I think we might safely say that a battalion 300 strong would not produce more than 250 trained soldiers for active service, and 750, or exactly 3 to 1, of new men, would have to be added to them to make up the authorised war strength. A battalion thus formed would no more be the same battalion that it was before than a watch with new works and a new case would be the same timepiece that it was before these improvements were made. So far as the men are concerned, therefore, time spent in the higher training of the battalion school would be lost.

But it may be questioned whether, if a man is not to belong for fighting purposes to the battalion in which he has been trained in peace time, the higher training is of much use to him.

The individual training of the man is chiefly to be obtained in the company school, where he is taught to make the most of the natural features of the ground, as well as to execute with intelligence the duties of outposts and advanced guards. The use of the higher training is chiefly to accustom the officers to fight in the larger units, and also to give homogeneity to the battalion. In this case the latter is impossible, and for the former the only practical way I can conceive is to combine two or more battalions into one for drill purposes.

NOTE BY THE AUTHOR.—It would be possible to devise a permanent combination of these battalions, but the necessary reorganisation might seem too drastic, and the subject is perhaps somewhat beyond the scope of this essay. Still I will give a brief outline of what I mean. Under the new system of the gradual relief of *officers* and men attached to the foreign battalion by those belonging to that at home, the relief of the battalion, as a whole, becomes a work of supererogation, a needless expense. Thus, when the time comes for relieving the battalion, many officers and men who have been out only a short time must be brought home, and their places taken by others who have been only at home a short time. Then in the next and succeeding years officers who have only lately been brought home will have to proceed abroad again. If this system be not carried out the relief of the battalion is merely a nominal, not a real one; if it be, it entails needless expense.

My first proposal is, therefore, to omit the relief of battalions, and to carry out the relief of individuals by drafts. We shall thus have seventy battalions of our army permanently abroad, and, as the home battalions, as such, will not have to go abroad, there will be no necessity for any different establishments among them, so far as this consideration is concerned. I shall thus have removed an objection to the scheme that I am about to propose, the advantages of which I shall afterwards discuss.

Instead of having seventy regiments of two battalions each, with a depôt centre, I would have thirty-five regiments of four battalions each—two at home, two abroad. The foreign battalions would be the same as at present. Of the two home battalions, one would be an active battalion, the other a depôt one. All recruits for the other three battalions would first join the depôt battalion—those for the home battalion remaining six months, those for India till the despatch of the next draft after they had completed one year's service.

In calculating the strength available for these regiments I will follow the figures already given in this paper:

Recruits required annually for seventy regiments abroad .	70 × 160 =	11,200
Recruits required every six months for home battalions .	35 × 120 =	4,200
Strength of thirty-five depôts	=	15,400
Ditto of each depôt	$\frac{15,400}{35} = 440$	
Total home strength taken as		42,040
Deduct strength of depôts		15,640
		26,400
Strength of each home battalion	$\frac{26,640}{35} =$	760

In comparing the strength of these home battalions with the present paper strength, we must add 120 recruits to it, which are with the depôt battalion, which would give us 880 per battalion. On mobilisation, however, these 120 recruits could only be counted upon as a resource to be made use of further on, and the battalion would have to be completed by 280 reserve men—not, however, an excessive proportion. In case of colonial wars the battalion would be strong enough as it stood, or, if it were deemed necessary, a portion of the Indian contingent next for embarkation might be taken from the depôt.

Our home army would thus consist of thirty-five battalions fit for active service, not including the Guards and the Mediterranean garrisons, which would give us more than enough for two army corps. Behind it would be thirty-five more cadres, which, by means of recruiting and reserve men, might be made to supply a second line, almost as strong in numbers, though not so good in quality, as the first.

Now before pointing out the advantages which I should claim for such a system, I wish to answer one or two objections, which I feel sure will be made against it.

First of all I shall be told that this is a further blow at the regimental *esprit de corps*—that officers will now have practically to belong to four regiments, and all feeling of comradeship, such as used to exist, will be gone. Well, first I will call to my aid all the arguments already used by the authorities in favour of linked battalions. Secondly, I would point out, what I for one believe to be quite true, that all officers have already protested that the link battalion system has killed *esprit de corps*. If it have, then this further change can do no more harm.

Then I may be told that my weak depôt battalions will not require so many officers as service battalions, while service with them will not be popular. With regard to the first I do not propose to go into details, as I do not think that in this essay questions of pure organisation, which do not affect training, should be included. But I would point out that, whether popular with the army or no, a reduction in the number of officers, could it be effected without loss of efficiency, would certainly be a gain to the country. That some such reduction could be made I believe, but to what extent I cannot say. But it does not necessarily follow that such a reduction must be made. Presumably, it it were effected, it would be because the authorities were convinced that it could safely and advantageously be done. As to service with the depôt being unpopular, I fancy that in some respects officers would like it, especially married officers, who would rejoice in the prospect of a prolonged stay in one place. But of course any officer who remained too long with the depôt would fall behind his comrades in proficiency, and therefore service there must be done by roster. As, however, nearly all regiments call out that they are under-officered, owing to the number of men away from their regiments from various causes, I would suggest that, supposing the total number of officers was not to be reduced, all such absentees should be borne on the strength of the depôt, while the active battalion should be maintained at its full strength; so that the proportion of officers serving with the depôt to that serving with the colours would, in most cases, be reduced to about two-and-a-half or three to four.

And now as to some of the advantages I claim for the system—

(1) I believe that by it we should obtain the largest number of real battalions which it is possible to form out of the men at our disposal, and at the least cost.

(2) That the whole of the battalions which we intend to mobilise would be of sufficient strength in peace time to allow of their receiving an efficient training.

(3) That it would be possible so to manipulate the recruiting and the Indian drafts as to allow the young soldiers to arrive at their service battalions in large batches, not in small driblets as at present, and thus facilitate the introduction of a systematic form of training, more nearly resembling that in the German service.

[NOTE BY MAJOR-GENERAL PORTER.—This Appendix is also, I consider, incomplete. With regard to the suggested objection that making regiments all consist of four battalions would still further destroy the spirit of *esprit de corps*, I would point out that this system now holds good in both of the Rifle regiments, as well as in the Guards. Ere long, the new four-battalioned regiments would have the same feeling amongst themselves.]

PAPER V.

REPORT OF THE RAILWAY OPERATIONS IN EGYPT DURING AUGUST AND SEPTEMBER 1882.

By Major W. A. J. Wallace, R.E.

On 6th July, while home on leave from India, I was summoned to the Horse Guards, and informed by the Inspector-General of Fortifications that a Military Railway Corps was about to be formed, and that I was to have charge of it.

The organisation and strength of the corps* having been determined upon, the officers, non-commissioned officers and men were selected, the equipment was proceeded with, and the purchase of the following railway plant, material, and stores was ordered:

4 Small tank locomotives.
2 1st Class carriages.
2 2nd " "
6 3rd " "
40 Cattle trucks.
4 Brake vans.
2 Travelling cranes.
2 Breakdown vans.
5 Miles of permanent way complete, with accessories, tools, &c.

While these articles were being procured and shipped, Sir Andrew Clarke, through the courtesy of Mr. Forbes, Chairman of the London, Chatham and Dover Railway, obtained permission for the officers and men of the 8th (Railway) Company, Royal Engineers, to have the run of that line and pick up what they could of railway working in the Locomotive and Traffic Departments, the Heads of those Departments, Mr. Kirtly and Mr. Mortimer Harris, affording every facility and assistance.

Similarly, opportunities of seeing practical platelaying were freely afforded by Mr. Brady and Mr. Jacomb, the Chief Engineers of the South-Eastern, and London and South-Western Railway Companies.

* 7 Officers, 1 Warrant Officer, 2 Buglers, and 97 Non-commissioned Officers and Sappers. For particulars *vide* Captain Sidney Smith's report appended.

These few days' training, giving, as they did, to intelligent men opportunities of seeing how work should be done, were of great use to us afterwards.

On the 2nd August I received orders to proceed with Captain D. A. Scott, R.E., *viâ* Brindisi, to Alexandria, there to report myself to the General Officer Commanding, and arrange with him for shipping to the base of operations such rolling stock, material, &c., as might be required.

We arrived at Alexandria on the 10th August, and carried out the above instructions. Lieutenant Willock was left behind in England to see to the shipping of the railway plant, and to follow with it and the 8th (Railway) Company, Royal Engineers, in the steamship 'Canadian.'

A meeting was held at Alexandria with Mr. Le Mesurier, C.S.I., and the principal officials of the Railway Administration, Brig.-General Nugent, C.B., C.R.E., attending. The terms upon which the rolling stock and materials were to be made over having been agreed upon, the necessary steps were taken for shipment to the base of operations. Two tank locomotives were purchased for £800 each from Messrs. Greenfield & Co., the smallest available engines being selected with a view to the difficulties of landing at Ismailia, where there were no facilities for dealing with heavy weights.

On the 19th August the general move from Alexandria took place. With it one tank locomotive, belonging to the Egyptian railway, 19 wagons, and some permanent way material were despatched as a first instalment; the locomotive, being too large for the hatchways, had to be carried on the deck of the steamship 'Osiris'; the wagons and permanent way materials were towed in two large barges, one of which foundered off Aboukir during the night. Subsequently four other locomotives, 19 wagons, and some more permanent way material (sufficient for about one mile of line in all) were packed in barges and similarly despatched by Captain Scott, who was ordered by the Commanding Royal Engineer to remain at Alexandria.

I arrived at Ismailia on the morning of the 21st, and was at once ordered by the Commander-in-Chief to repair the line as far as Nefiche (three miles). Taking 12 Sappers of the 17th Company, Royal Engineers, Captain Wood, R.E., accompanying, with 20 sailors, a truck and some rails, &c., we found the line cut in two places. The requisite repairs were soon effected, and on arrival at Nefiche, which had just been occupied by Major-General Graham's Brigade, we found, standing at the station, a train of 22 wagons, the leading one of which, loaded with coal, had been struck by a well-directed 7-inch shot from the Admiral's ship at Ismailia; the engine had been disconnected and removed by the enemy.

Finding the bridge and water supply at Nefiche intact, I recommended sending the engine and wagons to Suez, there being no means of landing them at Ismailia, the Admiralty vessel 'Recovery,' specially fitted for lifting heavy weights, not having yet arrived. But it was deemed expedient to wait till the enemy had been dislodged from certain strong positions which he occupied on the canal bank between Ismailia and Suez.

I obtained permission to commence next day laying a line of rails from the Station to the Central Landing Place (about 1,000 yards), but no working party was forthcoming (all hands being busy landing) till late in the afternoon, when at 7 P.M. 400 men of the Guards and King's Royal Rifles were placed at my disposal. With these the rails and sleepers were laid out by 11.30 P.M., when the moon went down.

The Commanding Royal Engineer then ordered me to proceed with the locomotive and wagons to Suez; I accordingly started at daybreak on the 23rd with Mons. Choissy, Assistant Locomotive Superintendent, Egyptian Railways, and a staff of 12 fitters, drivers, &c. Owing to delays and detentions in the Canal, due to grounding and meeting steamers conveying the Indian Contingent, we did not arrive at Suez till the night of the 24th.

The 25th and 26th were spent in landing and erecting the locomotive and wagons, valuable assistance being rendered by Capt. Hext, R.N., Chief Transport Officer, and also by some of the artificers of the Fleet, whose services were made available by Admiral Sir W. Hewett, V.C., K.C.B. Unfortunately twelve hours' delay was caused by the bursting of a tube just as we had got steam up in the locomotive; but Mons. Choissy worked with most praiseworthy energy through the night, and had the engine ready for the road by 8 A.M. on the 27th.

Expecting to meet with opposition and obstruction on the line to Ismailia, a 7-pr. gun was mounted in the leading truck, which was plated with ½-in. iron, and fitted up for its reception. This gun was manned by 10 sailors, commanded by Midshipman Beaumont, H.M.S. 'Euryalus'; a guard of half a Company, Madras Sappers, under the command of Colonel Brown, R.E., C.S.I., with Lieut. Burn Murdock, R.E., and a truckload of rails, sleepers, &c., for possible repairs, accompanied.

Leaving Suez about 9 A.M., we found the road in good order throughout, with ample water supply ready for use at Genefe and Fayed, and got to Ismailia without hindrance of any sort by 3 P.M.

The water supply at Nefiche had been neglected and allowed to run out in my absence, but this was rectified next day, and no similar failure occurred at this important station, upon which we had to depend entirely for water for engines until the advance reached Tel-el-Kebir on the 13th proximo.

The S.S. 'Canadian,' with the 8th (Railway) Company, Royal Engineers, had arrived at Ismailia on the 23rd August, late at night.

On the 28th August the train service from Ismailia towards the front was commenced, and the first train of supplies was run to Tel-el-Mahuta (about 8 miles from Nefiche), then the most advanced post, where the enemy had blocked the line by filling in a cutting. This obstruction was not entirely removed till the 30th, when the daily supply train ran through to Kassassin, 22 miles from Ismailia, and some 5 miles beyond the station of Mahsamah, where upwards of 100 vehicles had been captured—chiefly wagons, including one water tank on wheels, which proved of great service afterwards. There were no watering arrangements at Mahsamah, consequently the engine supply, which was one of our chief difficulties, continued and increased till the 13th, when the capture of Tel-el-Kebir, where there was an ample supply, put an end to the water difficulty.

The engines being all of small water capacity, tenders had to be improvised, the tanks brought from England for the purpose answering very well; but the pumps supplied from home were unsuitable, and their place had to be taken by fire-engine pumps obtained from the shipping. Supplementary tanks were placed at Ismailia, Tel-el-Mahuta, and Kassassin, and were kept constantly full by fatigue parties from the troops holding these posts.

On the 31st August the Railway Department was placed under the orders of Major-General Earle, C.S.I., commanding line of communications.

With a view to relieving the great pressure of traffic at and from the central pier, and to afford additional facilities for landing stores and material, a line of rails was projected from the Railway Station to the mouth of the Sweet-water Canal (about $1\frac{1}{4}$ miles), where lighters could approach the bank with ease.

On the 1st September the work was made over to the Indian Contingent, by whom it was completed in about a week. This line was not only a most convenient one for the transport of heavy goods, but it was also a great boon to the sick and wounded, who were conveyed by means of it to the door of the Base Hospital, which had been established in the Khedive's Palace.

On the 1st September the following rules for carrying on the railway service were drawn up with the approval of Major-General Earle:

1. The day before the departure of each train 24 trucks to be handed over by the Traffic Superintendent, Ismailia, to the Commissariat Department to load.

Three trucks will be provided for the Indian Commissariat Department daily for the present.

2. The Director of Railways hopes to run soon two or more trains daily to the front, one of which will be a mixed train.

Hours of departure to be settled by Director of Railways, and put in Orders.

3. As a rule, the supply trains will go straight to the Advanced Depôt, only stopping for railway purposes.

4. The mixed train will take supplies for intermediate posts.

5. An Officer or Senior Conductor to be in charge of stores, with way-bills; and if proceeding by mixed train, to know exactly what is to be delivered at each post.

6. An (R.E.) Officer or Non-commissioned Officer will be in railway charge of each train.

7. No Officer or man to proceed by train without a pass signed by the Commandant of the Base, or the Advanced Depôt, or a Railway Staff Officer. These passes will be inspected before a train starts off.

8. As a rule, horses and mules will not be conveyed by train.

9. In the case of Ordnance Stores, Artillery Equipment, &c., required to be forwarded by rail—a requisition for railway transport, stating the approximate weight and size of stores, to be forwarded the day previous to the Railway Staff Officer.

10. A telegram to be sent by the Railway Staff Officer on the departure of each train to each station where stores are to be delivered, to ensure regular fatigue parties being detailed.

11. A similar telegram to be sent by the Commandant, Advanced Depôt, for return trains, if necessary.

12. The tramway, from the landing wharf to the railway station, to be worked (under the supervision of the Railway Officers) and horsed by the Commissariat and Transport Department.

13. In order to secure the regularity of the Railway Service, it is essential that no person whatever should take it upon himself to interfere with the orders of the Director of Railways about traffic, stopping and delaying trains, &c.

14. The Officers employed on the Railway will on no account depart from the orders of the Director of Railways, and are not permitted to comply with any requests to stop or delay their trains at any but the authorised points.

The supply trains were worked with one engine till the 1st September, when two tank engines, purchased at Alexandria, arrived *viâ* Suez, where they had been landed and promptly erected by Mons. Choissy.

On the 5th September, four small tank engines arrived from England, and joined in the work on the following day.

Four and five small trains of eight to fifteen wagons, according to the power of the engine, were now run daily to the front, till the 11th, when two large goods engines, shipped at Alexandria, arrived *viâ* Suez, and the 200 yards of light rails used for hasty repairs near Magfar had been replaced by heavy ones.

The transport work was now rendered comparatively easy, these engines being able to draw trains of 35 loaded trucks. Upwards of 250 tons of supplies and baggage, in addition to details of troops, were carried to the front daily until the 13th idem, when the capture of Tel-el-Kebir and Zagazig placed at our disposal an ample supply of rolling stock for future requirements.

The following is a brief abstract of Railway traffic work done at Ismailia between the 28th August and 25th September, when the working of the branch lines was made over to the Egyptian Railway Administration:—

Eighty-eight trains in all were despatched from Ismailia, the principal items of contents being as follows:—

	Truck Loads
English and Indian Commissariat Stores	855
Regimental and Staff Baggage	178
Ammunition	20
Royal Artillery Guns and Wagons	9
Field Hospitals and Medical Stores	17
Royal Engineer Material	41
Clothing, &c.	19
Naval Brigade, with 6 Gatling guns	10
Passenger Carriages	71
Trucks for Soldiers	38
,, Horses	12
,, Empties	13
Permanent Way Material	20
Iron-plated Train for 40-pr. Armstrong, 1 Krupp, and 1 Gatling Gun	5
Total	1,308 equivalent to about 9,000 tons.*

In addition to the above, the sick and wounded, men and horses, were brought back from the front in the return trains to Ismailia; also additional was the work of moving the Army to Cairo when the general advance took place, besides clearing and carrying forward the large accumulations of supplies and stores which had been brought up by both rail and canal to the advanced depôts formed at Mahuta and Kassassin.

Very early in the morning of the 13th September, having made arrangements for providing a water supply for the engines at Kassassin, Major Ardagh and I left with a small locomotive pushing the iron-plated train, with the 40-pr. Armstrong in front, for Tel-el-Kebir, Captain Smith, Lieutenant Vidal, and Mr. Donald, Civilian Assistant-Engineer, following close behind in a train conveying 350 yards of permanent way material, with tools, &c., complete in every detail for repairs that were expected to be required. When we arrived in the

* This does not include casuals and details of all branches of the Service, who were carried in almost every train, sitting on the loaded wagons in numbers that averaged upwards of fifty men per train.

vicinity of the works the attack by our Infantry was just commencing; but owing to the hazy and uncertain light and ever-increasing smoke, it was found to be impossible for the 40-pr. to take any part in the fray, and the disappointed sailors had to look on while the enemy's shells burst provokingly all round them.

As soon as the position was carried the trains moved up, and the 8th Company men, assisted by a detachment of Madras Sappers, at once set to work to make a gap in the enemy's lines, which had been carried across the railway; and, though this part of the parapet had been constructed of clay mixed with sand and strong reeds (very tough, clinging stuff), the men worked with such goodwill that in less than two hours the trains were enabled to pass within the lines of Tel-el-Kebir, where upwards of 120 carriages and wagons were captured, many of the latter being filled with ammunition of all sorts mixed up with curious explosives, such as dynamite cartridges with detonators attached.

Later in the day I took the 40-pr. train, followed by a train carrying the head-quarters of the 2nd division, and pushed on to Zagazig, where I arrived some hours after the station had been occupied by Sir H. Macpherson, V.C., K.C.B., and where seven engines and 80 wagons had been captured.

The general move to Cairo commenced on the 15th September; this necessitated the employment of many heavily-laden trains for several days, and involved much hard, anxious, and trying work, carried on at a time when the telegraph, then only partially restored, was overwhelmed with messages and quite unable to meet the requirements of railway working, the notices of departures of the trains often not arriving at the forward station until after the arrival of the trains referred to. The necessity for a wire exclusively for railway messages was fully recognised by Colonel Webber, R.E., who had one supplied as soon as possible, but this was not in time for the greatest pressure of traffic.

The officers, non-commissioned officers, and men of the 8th (Railway) Company, Royal Engineers, had many difficulties to contend with, and much arduous duty to perform, both by day and night.

All hands worked willingly and well, and when it is borne in mind that they had little or no previous experience of railway business, the results achieved were, I submit, creditable on the whole.

A heavy and important traffic had to be carried on, working against time, in a trying climate, over a badly furnished railway, which had to be repaired under difficulties in some places, and in others was liable to be covered with sand and rendered unsafe without a moment's notice. For the said traffic there were available, at first, only a few shaky wagons of inferior construction, with feeble engines, brought round, one or two at a time, from Alexandria; the water difficulty in the desert was continual and increased with the advance; the native staff had deserted to a man, and there was no local labour procurable. But the work was done; not, however, without some mishaps (*vide* Appendix), such as engines breaking down, wagons getting off the rails, water supply failing, &c. &c., but without one single accident resulting in loss of life, or even serious injury.

Lieutenant Dopping Hepenstal unfortunately fell ill at the outset, and was invalided, thus throwing additional duty on the other Officers of the Company.

Lieutenant Huleatt worked most assiduously, and showed considerable aptitude in acquiring the duties of a Traffic Manager at Ismailia.

Lieutenant Vidal, who was our chief platelayer, superintended most of the repairs and renewals of the permanent way; he also laid in a siding for passing trains at Kassassin. Throughout he was ably supported by Serjeant Moat, Foreman Platelayer.

The Locomotive Department was judiciously and efficiently conducted by Serjeant-Major Loxton, assisted by Corporal Longcroft, who also took his share of the engine driving, and whose mechanical skill proved useful on several occasions.

The engine drivers had specially arduous duties to perform, and they acquitted themselves most creditably, often undergoing serious privation and discomfort during long hours of unavoidable detention, far from Head-Quarters, and without proper food or rest. I wish to bring prominently to notice Corporals Freeman, Saunders, and Garden, who had a large share of the most trying work.

The want of previous training in station duties, notably in shunting and marshalling wagons, making up trains, &c., was very much felt; but some of the station-masters and guards soon picked up a fair knowledge of their duties, which they carried out in a generally satisfactory manner. The following are deserving of special mention:—

Serjeant Pepperell, Station-master, Nefiche.
Corporal Penney, Guard.
,, J. Perry, Assistant Station-master.
Lance-Corporal Bradley, Station-master, Kassassin.
,, J. Waldron, Guard.

Although the line of communication did not at first exceed 20 miles in length, the 8th Company, Royal Engineers, proved numerically insufficient for the work to be done, owing partly to the whole of the native railway staff having deserted before our arrival (we had consequently to furnish from our limited numbers pointsmen, signalmen, greasers, engine cleaners, carriage examiners, &c.), and partly to the smallness of the engines necessitating a great number of trains, each of which required a full staff of guards, drivers, firemen, &c. On this being brought to the notice of the Commander-in-Chief, the officers commanding regiments were called upon to send in the names of any of their men who had ever worked on railways in the Locomotive or Traffic Departments. This call brought out a number of useful hands, who were a great help. Amongst those who rendered the most valuable service, I would name—

Serjeant Luscombe, 1st Black Watch, Royal Highlanders	Guards.
,, Jones, Royal Marine Light Infantry	
Lance-Corporal Thompson, Seaforth Highlanders	Firemen, Engine-cleaners, &c.
Private Connors, 19th Hussars	
,, Wardrobe ,,	
,, Ralph, Royal Irish Fusiliers	

Captain Sidney Smith, Royal Engineers, Commanding the 8th Company, took his full share of the hard work, acting on many occasions as conductor of trains, sometimes under very trying circumstances, when, owing to accidents or mishaps, long hours of night-duty were involved.

Lieutenant Walker, of the Royal Irish Fusiliers, rendered very useful service, running many trips as conductor of trains and performing the duties most successfully.

Captain England, of the same corps, acted once as a volunteer in the same capacity, when he showed a thorough knowledge of the work. He would have done more for us had not his regiment been just then ordered to the front.

My special acknowledgments and thanks are due to Major Ardagh, C.B., R.E., who was indeed a friend in need. He, although my senior in the Service, willingly lent a hand when the pressure was at its height, and the numerical inadequacy of the railway staff was most felt; his sound judgment, good advice, readiness of resource under difficulties, and, above all, his indomitable energy and good example, were of the greatest value, and contributed much to the success of the railway operations.

Captain D. A. Scott, R.E., performed excellent service, both at Alexandria and afterwards on the Ismailia-Cairo line, where he worked with indefatigable zeal and energy from the 2nd to the 25th September. Always ready to undertake any work, however arduous or irksome, he invariably carried it through to completion in a satisfactory manner. He is, moreover, an officer who has had considerable practical railway experience, which proved especially useful, the staff being generally new to the work.

From first to last every possible assistance was rendered by Mr. H. P. Le Mesurier, C.S.I., President of the Railway Administration, who placed the whole of his resources unreservedly at our disposal.

Amongst the members of his staff, who rendered the most valuable aid, I wish to bring specially to notice the following officers:

Mr. Donald, Assistant Engineer, arrived at Ismailia on the 4th September, having previously done good service with Major Ardagh at Alexandria; he worked with energy, and was of the greatest assistance both as an engineer and as a traffic officer, when we were very weak in the latter branch, the whole of the native staff having deserted; he conducted the difficult operation of relaying with full-sized rails some 220 yards of the main line between Nefiche and Mahuta, which had previously been hastily repaired with light rails. This work had to be carried out chiefly at night in order to interfere as little as possible with the train service to the front.

Monsieur Choissy, Assistant Locomotive Superintendent, personally superintended the erection, under great difficulties, of the whole of the rolling stock landed at Suez, where there were none of the usual facilities for the conduct of such work. By means of his energy and example the work was expeditiously and well done. We are much indebted to him for the very valuable service thus rendered.

Valuable service was also rendered by Mr. Carlisle, officiating Locomotive Superintendent, and Mr. Redmond, Carriage Superintendent, in the shipment of locomotives and carriages at Alexandria, also by Mr. Holzer, District Locomotive Superintendent at Zagazig, and Mr. Leete, Travelling Locomotive Inspector at Ismailia, who worked willingly and right well throughout a trying time.

I received much assistance from Colonel R. Harrison, C.B., R.E., A.A.G., whose exceptional knowledge of the duties and responsibilities of railway officials greatly facilitated our business relations; he always gave me the earliest and fullest information regarding the intended movements of troops, supplies, &c., but at the same time he was careful to avoid interfering in any way with the executive details of railway working.

W. A. J. WALLACE,
Major, R.E.

Cairo, 4th October, 1882.

APPENDIX I.

The following order was issued on the 10th September:

ESCORT FOR RAILWAY TRAINS.

In consequence of the advance of the Army and the necessity to guard the railway from damage by any of the small bodies of the enemy's cavalry, it is considered advisable by the General of Communications that, in addition to Cavalry Patrols, which have been ordered, a small armed party should accompany every train.

A guard should be detailed for this purpose by the Railway Staff Officer, formed, if possible, of men going up and down the line. Should none of these men be available, you should arrange for the Royal Engineers employed on the train (guards, engine driver, &c.), who should always take arms and ammunition, to be supplemented by as many armed men as you may consider necessary.

The Railway Staff Officer to be held responsible for informing you if any special guard is required.

To Major Wallace, R.E.,
Director of Railways,
Ismailia, 10*th September*, 1882.

APPENDIX II.

ABSTRACT OF ACCIDENTS, &c., BETWEEN THE 28TH AUGUST AND 25th SEPTEMBER.

Date	Nature of Accident	Damage to Rolling Stock and Permanent Way	Remarks
28th Aug.	Three wagons derailed at Nefiche points.	Trifling	Line was cleared by Captain Smith, R.E. Train detained 1½ hour.
29th "	One wagon derailed by sand on line near Mahuta.	Nil.	Accumulation of sand due to Cavalry crossing line to and from water. Train detained 1 hour.
30th "	Tender derailed by sand on line near Mahuta.	Nil.	Detention of 3 hours.
1st Sept.	Three wagons derailed from same cause at the same place.	Nil.	Train detained 2½ hours.
1st "	Train detained at Mahsameh by order of a Staff Officer and made to run an extra trip; ran short of water.	Nil.	Detention of several hours; three engines not home till 2.15 A.M. on 2nd September. Traffic arrangements for that day thrown out in consequence.
2nd "	Similar break down of two engines for want of water.	Nil.	Relief engine sent out at 1 A.M., brought the others in at 5 A.M. on 3rd September. Traffic arrangements thrown out.
6th "	Three wagons badly derailed at Mahsameh points.	Slight; two axle-boxes broken.	This accident was due to the pointsman, and caused a delay of 8 hours, the train not getting back to Ismailia till 3 A.M. on 7th September.
8th "	Engine broke down .	Nil.	
8th "	Tender derailed at Ismailia.	Slight.	The rails being out of gauge was the cause of this accident.
11th "	Tender derailed at Nefiche.	The body of the tender injured.	Accident due to defective tyre of wheel.
13th "	Two wagons of train derailed near Zagazig, while conveying headquarters of Division & Royal Highlanders	Trifling.	This accident was due to baggage animals getting in the way of the train; a detention of several hours was caused.
14th "	Points injured . .	Point rails and connecting rods broken at Abu Hammad and Zagazig.	This mischief was done by R.A. guns crossing the line, the result being serious interruption of traffic at a very busy time.
16th "	Tender derailed at Kassassin.	Nil.	Bundle of tents from stack alongside fell on line; detention trifling.
17th "	Two wagons derailed at facing points in Ismailia station yard.	Nil.	Detention of 1½ hour.
18th "	Engine, tender, & brake-van of train completely thrown off the line, about two miles east of Abu Hammad station, at 10.15 P.M.	The said rolling stock was seriously damaged.	The derailment was caused by a bundle of tents that had fallen from the preceding train. Fortunately nobody was hurt.

Cairo, *4th October*, 1882.

W. A. J. WALLACE, Major R.E.

APPENDIX III.

A Report on the Work performed by the 8th Company, Royal Engineers, during the Campaign in Egypt, 1882.

The 8th Company, Royal Engineers, on embarkation, consisted of:

Officers	4
Warrant Officer	1
Company Serjeant-Major	1
Serjeants	8
Buglers	2
Rank and file	88
Drivers	7
Total	111

Nearly all the men were selected with a view to their being suitable for all kinds of railway work, and consisted principally of fitters, engine drivers, smiths, carpenters, plumbers and clerks, with a few masons, boiler maker, coppersmiths, painters, &c., together with two tailors and a shoemaker.

Before leaving England these men were told off to various railway duties, which were slightly modified when we arrived in the country; the actual duties being as follows:

Company duties	5
Locomotive engine drivers	8
Firemen	6
Ice machine drivers	2
Locomotive superintendent	1
Running shed foreman	1
Engine repairers and cleaners	7
Inspectors and greasers	2
Guards	7
Station-masters	6
Ismailia station staff	6
Pointsmen	5
Storemen	2
Platelayers	20
Smiths	6
Carpenters and painter	5
Total	90

The remainder were employed at their trades as extra men whenever required, and to replace any men who were temporarily unfit for duty.

I took over the Company on the 13th of July, 1882, and between that time and the date of embarkation (8th August), through the courtesy of the London, Chatham and Dover and South-Western Railway Companies, portions of the Company were practised in platelaying, engine driving and firing, shunting, station duties, guards, &c., the men being allowed to do actual work in relaying the permanent way, travelling on the engines with the guard, marshalling and shunting trains, and taking turns in the signal boxes. The platelaying party was under the superintendence of Lieutenant Vidal, and the station party under Lieutenant Huleatt, whilst I superintended the engine drivers and parties generally. Lieutenant Dopping-Hepenstal and a few men of the Company went to Woolwich to assist in putting the locomotives and wagons on board the steamers.

During this time (about ten working days) the men undoubtedly picked up a large amount of useful information, which could have been learnt in no other way.

The Company embarked on the 8th August on board the steamship 'Canadian' (No. 17), and sailed on the 9th. There were no other troops on board her (except three Warrant Officers), and she had also five miles of permanent way, ten pairs of points and crossings, water tanks, condensers, wood and girders for a pier, and miscellaneous railway stores and tools. On the voyage lectures were given daily by the officers on marshalling trains, station duties, engine driving, platelaying, and railway duties generally, in addition to some given by the Medical Officer on temporary stoppage of bleeding, bandaging, carrying the wounded, &c.

The steamer went direct to Port Said, where she arrived on the evening of the 22nd August, and proceeded direct to Ismailia the next morning, where we arrived at 5 P.M., and took up our position in Lake Timsah.

On arrival, six men were sent ashore sick and, with the exception of these, only one man of the Company went to hospital during the whole time we were in the country. Some men had slight attacks of diarrhœa and sunstroke which kept them from work for a few days, but nothing more until the Company embarked for England, when a Serjeant and a Sapper (both of whom had been quartered at Nefiche the whole time) got enteric fever and were left behind at Alexandria; one man was left at Malta with dysentery, and at the present time there are four men in hospital suffering from debility and sores. Beyond these there were no casualties of any sort among the men. Lieutenant Dopping-Hepenstal was taken to hospital shortly after arrival and was sent to Cyprus; he returned for a few days and was ultimately sent home to England on the 20th September. No other officer was sent to replace him.

The behaviour of the men was all that could be desired, and they took great interest in their work. They often worked eighteen or twenty hours on a stretch, and the engine drivers and men in small detachments were sometimes without food for a very long time, as it was quite impossible to get rations for them, not knowing where they were. One non-commissioned officer was placed in arrest for insubordinate language and was severely reprimanded, but from the day of embarkation up to the present time there has not been a *single regimental entry* against any non-commissioned officer or man in the Company.

Some specially selected non-commissioned officers and privates from Cavalry and Infantry Regiments were attached to the Company at Ismailia, and assisted in the duties of guards, clerks, and firemen. As all the engines we got at first had no tenders, a truck with tanks on it was always attached to carry coal and water, and one man had to be constantly employed pumping water from these tanks into those on the engine, making three men to each engine. There was also a permanent fatigue party of Infantry detailed daily to coal, water, and assist in cleaning the engines and station yard.

Description of Line and Stations.

The line from Ismailia to Zagazig is a single one of the English gauge, the rails being the usual double-headed ones laid on 'pot' sleepers, which seemed to answer admirably in the sand, excepting when trucks went off the line and ran any distance; the wheels in this case broke the 'pots' and bent the tie-bars connecting them, thus narrowing the gauge. The sleepers taken out by us were different to these; they were long, hollow, sheet-iron ones with rounded ends, the chairs being screwed on to them with bolts and nuts. The keys, instead of being made of wood, were wrought-iron spiral springs, slightly tapering towards one end; in driving them in an iron core was used. The advantage of these was that they did not fall out, being always in a state of tension, wooden ones being liable to shrink. Both the sleepers and keys answered well. The line was, as a rule, nearly level, and the curves very easy; the steepest gradient was from Ismailia up to Nefiche.

The Ismailia Station consisted of a large stone building with telegraph offices, store rooms, ticket offices, &c., below, and three small rooms and a veranda upstairs. There was no turn-table, no engine pit, coal shed, or any means of watering. The goods station, about 150 yards off, had an office and a covered platform, at which four trucks could be loaded.

There were six lines in the station—

No. 1, or the Central Wharf Line.—This was of light rails, and only used for horse traffic to bring up stores from the central wharf; six horses could pull two trucks at a time. This was built by the Royal Engineers; it was about three-quarters of a mile in length, and was opened on the 29th of August.

No. 2, or the Goods Siding.—This was used for unloading the trucks, the English Commissariat and Ordnance Store Department using the platform, and the Indian Contingent loading from the ground between it and the passenger station.

No. 3, or the 'Middle Road.'—This was used for empties, and loaded trucks waiting to be marshalled.

No. 4, or the Main Line.—Trains were made up on this line, and started from the platform of the passenger station. This line was then kept clear for incoming trains to be discharged at the passenger station before being shunted on to the middle road.

No. 5, or the Engine Siding.—This was used by the engines to run round the trains. The engines stood at the lower end of the platform to be coaled and watered. This siding was not long enough when we had heavy engines, as they took such long trains, consequently the engines had to be brought out before the trains were made up.

No. 6, or the North Wharf Line.—This was built by the Indian Sappers and Miners, and was over a mile in length. It was worked by the shunting engines and principally used for trucks of forage. The wounded and sick were also sent to hospital by this line. It was opened on the 9th September for traffic.

The siding accommodation was often quite inadequate for the number of trucks which accumulated, the main line often having to be blocked, in order to carry out the shunting, thus causing great delays.

After our arrival, some tanks were fixed on a temporary staging, and water pumped up into them from a stand-pipe near the platform.

The rolling stock consisted of box-trucks, high-sided trucks, low-sided trucks, and rail trucks; these latter were very long, with six wheels. A very large percentage were box trucks; which were inconvenient for most stores.

The whole of the traffic arrangements at this station were carried out by Lieut. Huleatt, under the supervision of Major Wallace, R.E., Director of Railways, and the Officers of the Railway Staff.

Nefiche Station (2½ miles).—This station is on the main line from Zagazig to Suez, Ismailia being a branch line from it. The line here forms a triangle, by means of which engines were turned; there is also a larger water-tank and engine pit. The engines were always watered here, both going out and coming back, the tanks at Ismailia being only used for the shunting engines, or when absolutely necessary. On the station side of the triangle there were three lines, forming sidings, which were used for rolling stock when not required, or when the Ismailia yard became overcrowded.

Muhouta Station (10 miles).—This was simply a halting place on the line, where a camp had been formed. It was proposed at one time to put in a siding here for trains to cross, but it was not carried out, as the advance was made more quickly than was expected.

Mahsamah Station (16 miles).—Here there was a small stone station and telegraph office. This station had two lines where trains could cross each other, and formerly a third central line, which had been destroyed apparently by the enemy.

Kassassin Station (22 miles).—This was simply a halting place, where a camp had been formed, originally; but being a large camp, a siding 230 yards long was laid down here by the platelaying party of the 8th Company under Lieutenant Vidal, so that trains could pass, or a train could be unloaded without stopping the traffic.

Tel-el-Kebir Station (31 miles).—Here there was a small stone station and telegraph office, also watering arrangements. There were three lines through the station, an additional one on the west side, also a long blind siding curving off to the north, which had the appearance of being intended for a branch line.

Aboo Hamad Station (40 miles).—This was a small stone station with two lines through it, where trains could cross, also a loop outside.

Zagazig Station (48 miles).—This was a large junction connecting the Ismailia line with the two lines to Cairo, as well as to Tantah and the North. It had engine and repairing sheds, watering arrangements, and some miles of sidings. The main line from here to Cairo and also to Alexandria was a double one.

The great object in view was to take up to the front each day as many truckloads of stores, food, forage, &c., as the Commissariat and other departments could load up, and as we only had a limited supply of engines the trains were made up to as many trucks as the engines could move, pace not being so much an object as quantity. I do not think that on any one day we failed to move to the front the total amount of stores that were loaded up for us, and that we had stated we could take, though the last trains back frequently did not return until long after midnight.

There were many difficulties to contend with, the principal one, perhaps, being the priming of the engines, due to the very dirty water and to the boilers being never properly cleaned out. In peace time, the engines in Egypt used to have a 'shed' day every third day, while with us they were run a fortnight and sometimes longer without a chance of being cleaned. This priming reduced the speed very considerably and caused a great waste of water, thus increasing the difficulty of supply.

Until after the battle of Tel-el-Kebir, the only watering place we had was Nefiche, and it was only when no very great delays occurred that an engine drawing the usual heavy train could run from Nefiche to Kassassin and back without requiring extra water. In course of time we had tanks placed at Mahouta and Kassassin, which were filled from the canal and then the water was transferred to the engine tanks by buckets and pumps—a very laborious operation.

Another difficulty, due to sand and other impurities in the water, was that the injectors frequently got out of order and, on some occasions, when both broke down the train was brought to a standstill until another engine could be obtained.

The sand also caused delays in other ways. The troops used the railway to march along, the result being that the rails got covered, which acted as a very severe brake to the trains.

Furthermore, in the neighbourhood of camps, the Cavalry often had to cross the railway to water; this caused sand to accumulate on the rails, where it was usually forgotten (although ten minutes would have removed it); these accumulations were quite sufficient to throw trucks off the rails and, at Mahouta, this occurred three days running, causing delays of from one to three hours, but luckily on these occasions the trains were always running engine last.

The Royal Artillery gun carriages and other heavy carts, in marching along the line, invariably broke all the points they passed over, necessitating special parties going out to repair them before trains could pass. This occurred at Nefiche, Tel-el-Kebir, Aboo Hamad, and Zagazig.

The line being a single one, the telegraph was essential in order to arrange for trains to pass at crossing stations, but as nearly all messages were sent along the same wire, and this wire frequently broke down altogether, it was of very little use to us, and caused much delay, trains often waiting for each other at crossing stations three or four hours when they might have gone on.

Delays were also occasioned by stores and baggage being stacked too close to the rails, and in one instance trucks were thus thrown off the line. Working parties to unload the trains were not always obtainable, as men had frequently to stand to arms, and after long marches were too fatigued to work.

The entire management of the railways was in the hands of Major Wallace, R.E., Director of Railways; he was assisted by Captain D. A. Scott, R.E., and Lieutenant Willock, R.E., who formed the Railway Staff, in addition to the Officers of the 8th Company, Royal Engineers. A portion of the time we also had the assistance of Major Ardagh, C.B., R.E. Captain Scott was employed at Alexandria loading engines, collecting rolling stock, &c., for the first fortnight, and Lieutenant Willock's duties lay in disembarking and checking stores in addition to station work.

We first commenced work with one engine brought up from Suez by Major Wallace; it was a medium-sized side tank engine, English made, but rebuilt in Egypt. It had no blower, and its injectors were very bad. A few days later two more engines, of a smaller type and with saddle tanks, arrived from Suez, and by the end of a week our four English engines were brought up from the same place by Lieutenant Willock. Three of these were capable of taking from 10 to 12 loaded trucks each, and the fourth was a small engine used for shunting purposes. On the 9th September a full-sized goods engine with tender arrived from Suez, and another on the 11th, making a total of nine engines. After the battle of Tel-el-Kebir, we could get as many engines and wagons as we required.

The first few days we could only run one train a day, which took about 100 tons of food and stores to the front. On and after the 6th we ran three and sometimes four trains a day to Kassassin, leaving stores when required at Mahouta and Mahsamah, averaging about 40 trucks or 250 tons of stores per diem; and after the 13th we averaged 100 trucks or about 700 tons per diem to Cairo, until all the stores were cleared away from Tel-el-Kebir, Kassassin, Mahouta, and Ismailia, after which (25th September) the railway was handed over to the Egyptian authorities, the men of the 8th Company having gradually been withdrawn during the few previous days, and their places taken up by the native staff and superintendents. The next few days were employed in handing over and collecting stores, and on the 29th September the Company embarked for Alexandria *en route* for England.

(Signed) SIDNEY SMITH, Captain, R.E.
Commanding 8th (Railway) Company,
Royal Engineers.

CHATHAM, *6th November*, 1882.

APPENDIX IV.

List of Railway Material, Rolling Stock, and Stores, handed to Egyptian Railway Administration.

Description	No. or Quantity	Where at	Remarks
Steel rails, double headed, 70 lbs. per yard, 21 ft. long Do. 18 ft. "	For 5 miles line 2,614 71 About 585 tons	841 rails in line at or near Ismailia and Kassassin siding. 100 on trucks at Tel-el-Kebir. 1,744 at Alexandria.	
Sleepers, steel, buckled plates, with cast-iron chairs bolted on . .	For 5 miles of line. About 530 tons 7,990	2,485 in line at or near Ismailia and Kassassin. 350 on trucks at Tel-el-Kebir. 5,155 at Alexandria.	
Fish plates, steel, for above rails, pairs . . .	2,922	1,050 pairs in line or loaded on trucks. 1,872 pairs at Alexandria.	
Fish bolts, nuts, & washers, for above . . .	For 5 miles line	About 7 tons 5 cwt. in line, remainder at Alexandria.	
Spiral keys for chains .	For 5 miles line 100 cases .	46 cases used in line. 54 " at Alexandria.	
Points and crossings, complete, with wooden sleepers, switch rails, guard rails, chains, tools, &c.; 5 sets 1 in 10; 3 sets 1 in 8; 2 sets 1 in 12 .	10	2 sets laid at Kassassin. 4 sets laid at Ismailia. 4 " at Alexandria.	
Platelayers' tools, sets of—each consisting of $1\frac{3}{4}$-in. auger, $1\frac{5}{8}$-in. auger, 2 crowbars, 2 shovels, 2 picks, 6 spanners, 1 hand hammer, 1 keying hammer, 2 cold sets, 2 chisels, $1\frac{1}{2}$-pint oil can . .	10	Distributed along the line and at Ismailia.	

LIST OF RAILWAY MATERIAL, ROLLING STOCK, AND STORES—*continued.*

Description	No. or Quantity	Where at	Remarks
Long wood permanent way levers	20	10 at Ismailia. 10 at Alexandria.	
Screwing machine, to screw $\frac{1}{2}$ in., $\frac{5}{8}$ in., $\frac{3}{4}$ in., $\frac{7}{8}$ in., and 1 in. . . .	1	At Alexandria.	Case No. 37.
Drilling machine, with set of drills	1	At Alexandria.	Case No. 38.
Pot sleepers, cast-iron .	No. 1,279 . 53 tons 13 cwt.	At Alexandria.	
Tie bars for above sleepers	8 „ 2 „ 32 bundles .	At Alexandria.	
Tanks, galvanised iron, rectangular, 5 ft. × 3 ft. × 3 ft. 6 in., to hold 300 gals. each . . .	20	15 at Ismailia and on line. 5 at Alexandria.	
Brass cocks for galvanised tanks	20	1 at Ismailia. 19 at Alexandria.	
Tanks, steel, cylindrical, to hold 300 gals. each .	20	At Alexandria.	
Case, hose, and fittings, for cylindrical tanks . .	1	At Alexandria.	
LOCOMOTIVES.			
Small 6-wheeled coupled tank engines, by Manning & Wardle, Leeds, 1882; weight about 14 tons .	2	1 at Cairo. 1 at Ismailia.	
Small 4-wheeled coupled tank engine, by Manning & Wardle, Leeds, 1882; weight about $13\frac{1}{2}$ tons .	1	At Cairo.	
Small 4-wheeled coupled tank engine, by Manning & Wardle, Leeds, 1882; weight about $9\frac{1}{2}$ tons .	1	At Ismailia.	
6-wheeled tank engines, 4 wheels coupled, by Beyer & Peacock, Manchester; purchased from Messrs. Greenfield & Co., Alexandria, for £800 each . .	2	At Cairo.	
Spare parts for engines, by Manning & Wardle, including tubes, springs, valve chest covers, packing, gauge glasses, &c. cases	2	1 at Ismailia.	
10-ton travelling crane, complete . . .	1	At Nefiche.	
Spare wheels and axles for above . . pairs	3	At Suez.	

List of Railway Material, Rolling Stock, and Stores—*continued.*

Description	No. or Quantity	Where at	Remarks
Locomotives—*continued.*			
5-ton travelling crane, complete	1	At Nefiche.	
Spare wheels and axles for above . . pairs	2	At Suez.	
Break-down vans, to work with above-mentioned cranes, complete with tools, including screw hydraulic and traversing jacks, ramps, bars, chains, tackles, ropes, &c.	2	At Nefiche.	
1st class carriages	2	1 on line. 1 at Alexandria.	
2nd „ „	2	At work on line.	
3rd „ „	6	1 on line. 5 at Alexandria.	
Passenger brake van	1	At Alexandria.	
Goods brake vans	4	At work on line.	
Open goods wagons	20	4 on line. 16 at Alexandria.	
Cattle trucks	16	7 on line. 9 at Alexandria.	
Platelayers' trollies, large	2	1 at Suez. 1 at Ismailia.	
Platelayers' trollies, small	2	At Ismailia.	
Lamps.			
Carriage roof lamps	50	At Ismailia.	
Hand signal	50	38 at Ismailia. 12 on line.	
Train signal	32	At Ismailia.	
Water gauge	5	On engines.	
Cans, tin, oil, feeding	50	At Ismailia.	
Bottles, tin, oil 5 gals.	1	At Ismailia.	
Bottles, tin, turpentine	1	At Ismailia.	
Pumps, ships, force, with suction and delivery hose, complete	6	2 at Ismailia. 4 with engines on the line.	
Grease for wagons . . casks	29	13 at Ismailia. 16 at Alexandria.	
Oil, sweet . . gals.	23½	At Ismailia.	
Oil, colza „	6	At Ismailia.	
Oil, linseed „	30	At Ismailia.	
Cotton, waste . . cwts.	2	At Ismailia.	
Coal . . . . tons	600	580 tons, North Wharf 20 tons, Central Wharf	Ismailia.

Note.—S.S. 'Stelling' returned to England, having on board one passenger brake-van, and four cattle-trucks.

PAPER VI.

KAFR DOWAR,

THE POSITION HELD BY THE EGYPTIANS UNDER ARABI FROM JULY TO SEPTEMBER 1882.

BY LIEUTENANT S. D. CLEEVE, R.E.

GENERAL DESCRIPTION OF COUNTRY (Pl. I.).—The country defended is the narrow strip of land between Malaha Junction and Kafr Dowar stations on the railway from Alexandria to Cairo, or a length of about 10 miles, the average width being about $1\frac{1}{2}$ mile, from Lake Aboukir on the north to Lake Mareotis on the south side. The Mahmoudieh canal and railway run almost parallel to each other through the whole length of country, the former having a bank on both sides, and the latter being carried on an embankment nearly all the way.

NATURE OF THE GROUND.—The whole of the ground near the canal and railway banks is cultivated in places, but there are marshes and swamps at intervals as far as the third position or line of defence, and all the country is intersected by irrigation ditches in connection with the canal.

All traffic is carried on by means of the canal and railway embankments, but wheeled traffic could only move along the latter.

Lakes Aboukir and Mareotis were dry enough from July to September to allow of cavalry or infantry moving with considerable freedom on their borders.

GENERAL REMARKS ON THE DEFENCE.—From the description of the ground it will be seen that the position is one of great natural strength and well adapted for defence.

The works constructed by the Egyptians consisted chiefly of heavy and carefully built earthern batteries, the largest containing twenty-one, and the smallest three, guns, connected with each other by shelter trenches or musketry parapets, and the majority being fronted by wet ditches.

There were emplacements for 100 guns (in eighteen batteries and seven epaulments) in the whole position, ninety-eight being embrasures for Krupp field guns and of the remaining two, one being for a 7-in. M.L.R. Armstrong gun, the other for a 15-centimetre Krupp gun, both of these being mounted in the large battery (No. VI.) facing our position at Ramleh.

The parapets vary in thickness from 25 to 40 feet.

In the gun batteries the crest averages 7 feet above terreplein; the guns are from 20 to 40 feet apart; there are no banquettes for musketry, but several of the batteries have covered ways in front.

In most of the works there is a great want of splinter-proof traverses; in some cases there are as many as five guns in line without any traverses between them.

Magazines are provided in traverses at the rate of about one for three guns, except in five of the outlying batteries of the first position, where there was no accommodation, and the guns would have been entirely dependent on their limbers and ammunition carts. Details of a magazine in a traverse are shown in Pl. III. They are all of similar construction with about four feet of earth protection, but only about half of them were provided with doors, and these of very light timber ($\frac{3}{4}$-inch).

The gun platforms, made of 6-inch × 9-inch baulks, were all of similar construction. Details of one are given in Pl. III.

Sites of Batteries.—The positions of the gun batteries are well chosen; in most cases the ground is marshy in front in addition to the wet ditch, but when this is not the case no attention appears to have been bestowed upon the construction of artificial obstacles, and the absence of musketry fire from the parapets would have been an additional source of weakness.

Shelter Trenches.—Some of the shelter trenches are also too high for efficient musketry fire, reaching in some cases a height of 5 feet.

The Three Lines of Defence (Pl. I.).—The position is divided into three separate lines of defence, or three independent positions.

(I.) Consists of eight batteries and seven gun epaulments, or a total of fifty-two gun emplacements, and several lines of shelter trench.

(II.) Consists of six batteries or twenty-three gun emplacements; three of the batteries being connected by musketry parapets and the remaining three detached. This position is about four miles behind the first.

(III.) Consists of four batteries or twenty-five gun emplacements connected by musketry parapets, and all in one line. This line of defence is about two miles behind the second, and two miles from the reserve camp at Kafr Dowar station.

Description of First Position, or Line of Defence.
(Pl. I. and II.)

The right of the first position rests on the marshy border of Lake Aboukir, and the left on Lake Mareotis; the total length of the line being about 1½ mile in a direction perpendicular to the railway and canal.

There are two main batteries in this line, *i.e.*, Nos. VI. and VII., which are connected with each other and with Lake Aboukir by indented lines of shelter trench. The remaining six batteries are detached, five being in front of the main line and on the banks of the canal (where there are also seven gun epaulments), the sixth being thrown back on the right flank on the Aboukir lake to check any turning movement in that direction.

Unfinished Work.—A new work, bastion trace with long flank, was just commenced on the extreme left of the first position, to protect that flank on the lake becoming dry, but this work was not sufficiently advanced to show the intended armament, or whether for musketry defence only.

A short flank was also being built on the left of No. VI. battery, but it does not show whether additional armament was in contemplation here.

Description of the Batteries (Pl. I. and II.).—No. I. Three guns, no magazines; near the scattered palm trees on the right bank of the canal. A half-sunken battery; no ditch in front; parapet 15 feet thick.

No. II. (Pl. I and II.)—Three guns, one magazine; on left bank of canal opposite No. I. Three semicircular epaulments converted into a battery; no ditch in front; parapet 12 feet thick and 7 feet high; magazine in traverse between second and third guns.

No. III. (Pl. I. and II.)—Three guns, no magazines; similar to No. I.; situated on the right bank of the canal.

No. IV. (Pl. I. and II.)—Three guns, one magazine; similar to No. II.; situated on the left bank of the canal, opposite to No. III.

No. V. (Pl. I. and II.)—Two guns, no magazine; in rear of No. IV. on the left bank of the canal. Two gun epaulments converted into a battery, and one epaulment for a limber separated by a traverse from the second gun; parapet, &c., same as in No. II.

No. VI. (Pl. I. and II.)—Twenty-one guns, six magazines. The largest battery in the whole position, extending across both the railway and canal, forming part of the dam across the latter. A roadway passes through this work on the left bank of the canal. On the right bank of the canal and on the dam itself there are eight embrasures; in the remainder of the work there are thirteen, including the 7-inch M.L.R. Armstrong over the railway on a masonry platform, and the 15-centimetre Krupp gun the tenth emplacement from the left. All these guns command the ground in front; the average relief is 35 feet; the parapet varies in thickness from 30 feet to 40 feet; a wet ditch, 140 feet wide, fronts the left half of the work, and a covered way with two traverses gives about 90 yards in length of musketry parapet in front of the ditch, which is the only provision for musketry fire in the whole of this battery. There are seven traverses in the battery, six of which contain magazines of the ordinary size. There is a large traverse 300 yards in rear of this battery, 25 feet high and 60 feet thick, extending from railway to canal bank, and defilading the camp in rear of it, which was found full of horses when the position was surrendered.

No. VII. (Pl. I. and II.)—Five guns, no magazines; situated on the left of the first position; parapet 25 feet thick and no traverses. This work was of recent construction, and was finished just before the end of the campaign. The working parties employed could be distinctly seen from Ramleh.

No. VIII. (Pl. I. and III.)—Five guns, no magazines; thrown back on the right flank of the first position on the Aboukir side of the canal; no gun platforms and no traverses. A wet ditch with indentations passes in front of this work from the canal to Lake Aboukir, about 10 feet wide with banks thrown up on both sides.

Gun Epaulments (Pl. I. and II.).—There are seven gun epaulments on the banks of the canal in front of the main line of the works of the first position, all of semi-circular trace; parapets 12 feet thick, relief 7 feet; the earth for the construction of these epaulments is carried from the surrounding ground; none of them have ditches.

Limber Epaulments.—There are three similar epaulments for limbers near those for the guns, the former having no embrasures.

Shelter Trenches.—The shelter trenches are of very variable sections, some being converted irrigation ditches; some of the parapets are too high for efficient musketry fire; in most cases the interior slopes and crest lines are revetted with mud and straw.

All the trenches on the right bank of the canal extend to the marshy border of Lake Aboukir, where they end in a flank thrown back to protect the right. (Pl. I.)

Description of Second Position, or Line of Defence. (Pl. I. and IV.)

The second position, about four miles behind the first, extends like the latter from the edge of Lake Aboukir on the right to that of Mareotis on the left; but the line is not straight, the right being thrown out in front of the left as can be seen on the plan. (Pl. I.)

There are four batteries in the main line, *i.e.*, Nos. IX., X., XI. and XII., the two former on the banks of the canal; No. IX. being connected with Lake Aboukir by a shelter trench. Nos. X. and XI. are joined by a curved and indented line of musketry parapet, and all fronted by a wet ditch, and Nos. XI. and XII. are connected by a shelter trench, which extends to the left of No. XII., completing the line to Lake Mareotis. The two detached batteries in rear of the above line are Nos. XIII. and XIV.; the former, three-fourths of a mile behind No. XI., commands its interior, and the latter, three-fourths of a mile behind No. XIII., is situated by itself on the right bank of the canal.

Description of the Batteries (No. IX.).—Three guns, one magazine; on the right bank of the canal; an unfinished batttery with two traverses (one containing the magazine) and no gun platforms. The section is similar to No. XIV. (Pl. IV.); the earth for the construction of the battery was taken from the ground in front and rear, which is rough, marshy, and in places under water.

No. X.—Three guns, one magazine; situated on the left bank of the canal opposite No. IX.; an unfinished battery with two traverses (one containing the magazine) and no gun platforms. Relief 35 feet, average thickness of parapet 25 feet. This battery forms the right of the line of musketry parapet, which extends to No. XI., and all of which is fronted by a wet ditch communicating with the canal, and of average width, 20 feet.

No. XI. (Pl. IV.)—Six guns, two magazines; situated on elevated ground about half way between the canal and the railway, and forming the left of the musketry parapet communicating with No. X. Relief 40 feet, terreplein 30 feet over ground in rear. Wet ditch and covered way for musketry.

No. XII. (Pl. IV.)—Three guns, one magazine; on the left bank of the railway and connected with Lake Mareotis marsh by a shelter trench, forming the left of the line of defence.

No. XIII.—Four guns, two magazines; situated on slightly elevated ground, three-fourths of a mile behind No. XI. and commanding its interior; there is no ditch to this battery, the parapets and slopes are unfinished, and there are no platforms; relief over ground in front 10 feet; relief over ground in rear 25 feet.

No. XIV. (Pl. IV.)—Four guns, two magazines; situated on the right bank of the canal, three-fourths of a mile behind No. XIII. There are two traverses on the gun terreplein containing one magazine each, and a long traverse 9 feet high on the lower terreplein. The earth for the construction of the battery was taken from both in front and rear, as in No. IX., the ground being in consequence broken and wet.

Musketry Parapets and Shelter Trenches (Pl. I. and IV.).—A shelter trench, giving 4 feet 6 inches of cover, extends from battery No. IX. to the Aboukir Lake on the right of the second line, with a right angle branch about the centre; the ground in front of it is marshy, and in rear chiefly sand.

Musketry parapet in a curved line with one small salient and two indentations, all fronted by a wet ditch; has already been referred to as connecting batteries X. and XI.; details are given on Pl. IV.

A shelter trench connects No. XI. with the railway opposite No. XII., and from the latter extends to Lake Mareotis, the section throughout giving about 4 feet 6 inches cover.

Description of Third Position, or Line of Defence.

(Pl. I. and V.)

The third position or line of defence lies about two miles behind the second, and about the same distance in front of the reserve camp at Kafir Dowar station. There are four batteries (Nos. XV. to XVIII.) in this position, connected by musketry parapets loopholed nearly all the way and fronted opposite the loopholes by a wet ditch. There are no outlying works in this line of defence, the right of which rests on the left bank of the canal, and the left, forming battery No. XVIII., terminates on the edge of Lake Mareotis, the railway passing through the entrenchments about the centre of the position.

Description of the Batteries. No. XV. (Pl. V.).—Twelve guns, four magazines; situated on the left bank of the canal, extending to the left about 150 yards, when the line of defence is broken by a road and the musketry banquette is continued to the railway. There is nothing special to note in this battery, except that in front of the salient there is a traverse in the ditch and a covered way, and a large traverse on the terreplein of the salient protects the line from enfilade.

Nos. XVI. and XVII. (Pl. V.)—These batteries, containing three guns and two magazines each, are exactly the same, one on the right, the other on the left of the railway; there is nothing special to mention in describing them, except that they are fronted by a wet ditch about 40 feet wide and 5 feet deep, containing about one foot of water.

No. XVIII. (Pl. V.)—Seven guns, two magazines; situated on the extreme left of the third line, and has a wet ditch; there is nothing special to mention in this battery.

Musketry Parapets (Pl. I and V).—The musketry parapet, connecting the four batteries in the third position, is traced with a slight salient at the railway, and the portion on the left of this has a re-entering angle, about half way, of 158°. Loopholes or musketry embrasures extend nearly the whole length of the line, and are most carefully made of mud and straw, of the dimensions shown in Pl. V. Earth was taken partly from the front and partly from the rear.

Communications.

Railway.—The railway was destroyed by tearing up the rails in front of the first position at intervals extending over a length of $1\frac{1}{4}$ mile. Inside the first entrenchments (*i.e.*, battery No. VI), both lines of the railway were found in good working order the whole way, and there were apparently no preparations made for demolition in case of a retreat.

Canal.

Dams (Pl. I and II.).—Two dams were built across the canal to shut off the water supply of Alexandria, and to give an increased head of water for flooding the ditches and grounds throughout the positions. The first dam formed part of No. VI. battery and carried three field guns; it was made of earth and straw, revetted with mud, and 120 feet in average thickness. The second dam, about $1\frac{1}{4}$ mile further up the canal, was 50 feet in width, and similarly made to the first, except that it was kept up by means of piles and rough sheeting on both sides. Both of these dams were used for passage of troops across the canal.

Bridges (Pl. I. and II.).—Between Nos. III. and IV. batteries, in front of the first position, there were earth ramps extending into the water, within about 100 feet of each other; there seems to have been either a light bridge here or some arrangement for crossing the water by rafts.

A large bridge of barges existed across the water at Kaf Dowar camp, but this could be cut if necessary to let boats through, and there did not appear to have been any other obstruction to navigation above the second dam.

CAMPS (Pl. I.).—The positions of the Egyptian encampments are shown on Pl. I.

There were small camps for Horse or Field Artillery immediately in rear of each position; the main camps were behind the first line of defence, extending to the rear for about three miles, and the reserve behind the third position between Kafr Dowar station and the canal. Outposts were encamped in front of the first position, nearly opposite the scattered Palms, and on the north side of the canal at the second dam, and at batteries Nos. IX. and XIV.

There was nothing to note in the camping grounds, except, perhaps, the method of feeding the horses. Each animal was picketed near a circular mud block about 2 feet 6 inches high, and in some cases having a tin, or the end of a bell railway sleeper, inverted in the bottom of the basin, which was a hollow in the top of the block into which the forage was placed. (Pl. V.)

S. D. C.

ALEXANDRIA: 2nd Nov., 1882.

PAPER No. VII.

NOTES UPON NARROW-GAUGE ROLLING STOCK.

By Major J. R. Hogg, R.E.

The following notes relate to the use of the 18-inch gauge of rail upon defence works, which have been for some time in progress by means of convict labour, and are intended rather as a general description of the motive power and vehicles which have been under the test of continuous work, than as advocacy of a gauge so narrow in cases where economy is the chief desideratum. A talented civil engineer having on one occasion been invited to lecture at Chatham upon the structure and appliances of narrow-gauge railways, preferred, with good reason, to style his subject 'light railways' rather than one which might appear intended to reopen the gauge controversy which followed, some years ago, the construction of narrow-gauge lines of rail in North Wales.

It may suffice here to state that the choice of gauge for the works near Chatham was not a free one; the War Department had at its disposal some 18-inch gauge locomotives of special design, which had been constructed for possible military requirements, and their possession, as unemployed capital, decided the question.

That narrow-gauge rail lines for the execution of works, such as those of an entrenched camp, especially if by convict labour, secure certain advantages has been fully proved, and these may be summed up as follows:

1. Easy application to the contour of the ground surface.
2. Ready combination of branches of 'portable rail' with the permanent way of the steam line without change of rolling stock.
3. Lightness of rolling stock for hand-shunting and running trucks to tip without employing horses.

On the other hand, the disadvantages are:

4. Comparatively high cost of the steam traffic per ton of freight.

5. Need for extra care in the maintenance of permanent way in a condition safe for traffic at fair speed.

6. Great restraint in structural details of engines and of rolling stock generally, prejudicial to their durability in working order.

Locomotives.

Plate I. illustrates in longitudinal section the general proportions of one of the locomotives, which, by their presence in War Department store, decided the choice of 18-inch gauge ; carrying, perched in front, a steam-winding crab, and being fitted with rail clutches of 'Handyside' pattern, in order to use the winding rope upon inclines, they have become locally styled 'the Handysides.' It is, perhaps, just as well that these engines were not actually required for war service, their build presenting so many weak points which only admit of temporary and partial remedy, and which very soon showed themselves under the test of the very duty for which the engines were specially intended, viz., traffic upon rough lines of rail, with curves, or rather elbows, of great sharpness and continually liable to distortion. Nevertheless, it is unfortunate that the skill of the constructor was so heavily taxed, an exceedingly difficult problem with such a gauge having been given to him to solve.

The mounting of the crab engine upon the same frame with the locomotive, and the desire to make the latter take such sharp curves, restricted the boiler and tank capacity, and, at the same time, seriously interfered with the longitudinal frame rigidity ; the overhang beyond the driving wheel base brings too great a strain upon the Bissell trucks, of the form employed, to allow them to radiate with sufficient freedom, the result being a succession of transverse strains and shocks, even when running at very low speed, which start open the steam joints, and very frequently necessitate a lie-up for repairs. In order to get at the running gear over the frame sides, the boilers have been mounted so high, for the gauge, their axis 4 ft. 9 in. above the rails, as to give these engines a very unstable appearance; but the actual stability at speeds not exceeding ten miles an hour has turned out to be fairly satisfactory. Of course a run-off at that speed might be expected to cause a capsize ; the fact that no such accident has occurred in nearly four years of traffic upon a line of rail having little or no ballast below the sleepers may perhaps be taken as proof that the degree of stability meets the special purposes of the design.

On the whole, although very frequent repairs have been necessary in order to keep these engines under steam, they may be said to have performed a fair amount of work under rough conditions. Their fuel consumption in full work is at the rate equivalent to 67 lbs. of good smokeless Welsh coal per hour, and the water consumption about 61 gallons in the same time. The substitution of inspirator-feeding for supply by means of the pump fixed across the frame at P has much helped the steam economy under heavy stress of work; but the small boiler and tank capacity not only makes this steam economy a difficult task to the driver, but restricts the running range of the engine to very short distances from watering stations. In good state of repair the rail traction, with 140 lbs. of boiler pressure, is nearly one ton, but it has been difficult to maintain on an average more than two-thirds of this power.

For some months, one of these engines was employed in hauling loads of gravel, &c., up an incline, graded $\frac{1}{16}$ for 500 yards and $\frac{1}{25}$ for 1,800 yards further, the maximum gross train load possible being about 10 tons; but it soon became evident that the steam wear and tear was ruinous, and this duty was consequently discontinued as soon as it became possible to conduct the haulage by means of a winding drum driven by a fixed engine.

The steam winding crab mounted in front of the 'Handyside' is practically useless in that position as a haulage apparatus for loads in rear of the engine, although it is just possible to pass the winding rope back between the wheels along a straight piece of incline.

It can, of course, be turned to account in other ways, and has been found very useful in hauling a gross truckload of $3\frac{1}{2}$ tons up an incline of 1 in 5 from the excavation of a fort ditch, at a good speed of rope; and, in another position, the winding-drum barrel has been used very effectively as a shaft pulley in driving concrete mixers, &c., by means of a belt.

When it became evident that the 'Handysides' could not be relied upon for regular train service in the transport of convicts upon the defence works, and, generally, that a more efficient type of engine was needed, attention was directed to the flexible wheel-base system as applied by Mr. Percival Heywood, of Duffield Bank, Derbyshire, to an experimental engine of 15-inch gauge and 3 tons in weight, which he has constructed. Some account of this engine was published in the issue of the 'Engineer' for July 15th, 1881.

This system may roughly be described as the employment of sleeve axles upon which the wheels are keyed, and which are allowed play upon the engine axles which they encase, the latter being rigidly parallel and carrying the frame in the usual manner. The leading and trailing engine axles drive their sleeves by means of central ball-joints, and these sleeves are wide open trunks to allow radial play within themselves; the middle engine axle (or pair of axles, if it be desired to build the engine eight-coupled) rides in a close-fitting sleeve, drives the latter by means of a straight key, and is capable only of straight transverse motion within it, according to the limit of curve radius for which the engine may be designed.

The leading and trailing axle sleeves are so linked to the central one as to enable it to draw them into convergence upon the centre of rail curvature by the mere action of the lateral sliding upon its encased engine axle which this curvature causes.

The power of Mr. Heywood's experimental engine, in utilising its whole weight for driving adhesion, is fully established; it will haul a trainload equal to that weight up an incline of 1 in 10, even when the rails are hardly dry.

The opinions of the system which have been expressed by eminent authorities upon locomotive structure lead only to the conclusion that its non-application, as yet, is mainly due to the small demand that has existed for engines of less than metre gauge.

Plate II. exhibits the main features of an engine designed by Major English, R.E., constructed at the works of the Vulcan Foundry Company, Newton-le-Willows, and which has now been running for some months upon the defence works. Its weight, in driving order, was at first $9\frac{3}{4}$ tons, but was increased to 10 tons by substituting 5 cwt. of iron for the woodwork of the front buffer-block at B; this additional head weight, without setting up any forward oscillation, has enabled the engine to haul without difficulty ten loaded convict carriages, weighing about 38 tons, upon a gradient of 1 in 50.

Its tractive force is just half as great again as that of the 'Handyside,' when the latter is in high working condition, but it is incomparably its superior in maintenance of power. The strong frame structure, in which steel has been freely used, the good boiler capacity, and the steady longitudinal balance, have, in the hands of skilful constructors, combined to turn out an engine of great value for its special purpose. The rocking crutch-bearing upon the trailing Bissell truck has answered well in saving the main frame from the racking strains which are so injurious to the 'Handyside.'

The fuel consumption of this engine, in full work, is at the rate equivalent to 69 lbs. of good smokeless Welsh coal per hour, the water consumption in the same time about 66 gallons.

Tip Trucks.

For simple transport of stores or materials, the size of vehicles employed does not seriously affect the principles of rolling-stock design, the tonnage of freight for a given train length being variously proportionate to the gauge, but the latter becomes a ruling consideration in the design of tip-trucks.

For all embankment formation with the standard main-line gauge of rail an efficient end tip-truck is the first consideration, and its best proportions are consequently as familiar to the navvy as are those of the wheelbarrow. Upon a gauge as narrow as 18 inches the structure of such a truck is not so well known, but forms a problem into which cost enters as a very troublesome factor.

A number of trucks have been constructed for the works by the Lancaster Wagon Company, arranged for all-round tip, the bodies being mounted rather high, for stability upon the gauge, and swivelling upon turntable plates, but their structure is expensive, on account of its inherent weakness and fragility. More than one rolling-stock firm confessed that they did not see their way towards a satisfactory design of end tip-trucks of the capacity desired, viz., 20 cubic feet, although, of course, the structure for side tipping presented no difficulty whatever.

A solution of the problem was soon suggested by Sergt.-Major F. George, R.E.; if the top formation of the embankment, such as that of a rampart, be not less than 40 ft. in width, then, by the use of braced portable rail of 1 ft. 6 in. gauge, the work can be carried forward easily by side tipping alone, the rail line simply forming a loop, like the frame of a racquet bat, the curved head of the latter, or the whole loop and switch, being shifted bodily forward by hand, yard by yard, as the work grows. This system has been applied very satisfactorily, and has had a further application; trucks brought up from excavation by locomotive have been run to side tip forward, the train encircling the engine whilst it stood upon a central tongue of rail, from three-throw switch, in readiness to return with the empties; it sufficed to support the switch and central tongue upon loose timber sleepers, without spiking down, and to replace the portable rail in rear of the points by spiked roadway as the bank advanced.

After much experiment with various contrivances the design of truck arrived at, which appears to answer best for this kind of work, is illustrated by Pl. III. The proportionate tare weight is higher than what is customary in contractor's rolling stock of ordinary gauge, but can hardly be reduced except by the free use of steel, and consequent increase of cost.

Trucks of this pattern are very convenient for hand shunting by convict labour, without the aid of horses.

Bogie Wagons.

For simple transport of materials, without any tipping arrangement, a much more satisfactory tare proportion, than with trucks, is obtained by the use of the bogie wagon, a good design of which is shown upon Pl. IV. By lowering the hinged side-boards and strutting them apart beneath the body it forms a carriage for 26 men, and had its use been possible for convict transport, the cost of the latter, by means of closed carriages, could have been reduced by nearly one-half.

Closed Carriages.

The pattern of carriage adopted for the transport of convicts is shown upon Plate V.; the chief features of the design are similar to those of some of the carriages in use upon the Festiniog and Snowdon-Ranger-lines in North Wales.

The first carriage constructed for experiment required some minor alterations, but its main proportions were untouched, and the design may be said to have met every requirement; it has stood the test of more than two years' constant traffic without accident, and the daily passenger freight between Borstal and Horsted now exceeds 300 men upon each trip.

Some difficulty was met with in the structure of the bogies, it having been necessary to conform to the very low draw-bar level of the 'Handyside' engines. Of course, the proper point of draw-bar attachment to the bogie pin would be between the iron saddle of the main frame and the top of the bogie transom, but, in order to avoid the use of bent draw-bars, the attachment has been made as shown, at some exposure to buckling strains, but the latter have done no harm.

The convicts not being sent out upon the works in very stormy weather, these carriages have escaped risk of being blown over, but they have been driven in high winds without apparent danger to stability, the rail gate spaces relieving the side pressure.

A more rapid method of securing and releasing these rail gates than by the use of their stock locks has now been introduced, a chain being fed along the side of the carriage through sliding gate bolts and padlocked at its end.

General Remarks upon Gauge.

The cause of the employment of so narrow a gauge as 18 inches has been mentioned in preface; had it not existed a wider one would doubtless have been chosen and would have turned out more economical in working as well as in establishment. A gauge of 2 ft. 6 in. would appear to promise the best results in employment for the special purposes described, and would be far superior to that adopted in the following respects :

1. Admitting comparatively sharp rail curvature, it is easy to apply to the contour of the ground without heavy formation work; indeed, as regards the formation width, it is on a par with the 18-inch gauge, for the latter requires, for stability of traffic, sleepers fully 5 feet in length, and they may with advantage be even longer.

2. Upon a 2 ft. 6 in. gauge the rolling stock would still be sufficiently light for rapid hand-shunting and tipping, though being more capacious.

3. This gauge is not too wide for the use of portable rail in combination with the permanent way.

4. The permanent way would not need such jealous tending in order to maintain it in safe condition for traffic.

5. The cost of the traffic per ton of freight would show considerable economy upon that which the 18-inch gauge involves.

6. Almost all the conditions opposing efficiency in locomotives of 18-inch gauge disappear with the liberation from the restraints of the latter. Upon a gauge of 2 ft. 6 in. a good boiler and saddle tank can be carried without blocking up access to the gear of the engine within the frame, and the duty of any Bissell truck added may be mainly that of steadying the latter against longitudinal oscillation instead of diverting so much of the engine weight from useful driving adhesion.

7. Whilst all rolling stock may, upon the wider gauge, without serious increase of cost, be more substantially and durably built, the proportion of tare weight to gross trainload can be reduced, and so can also, for a given freight, the train resistance due to curvature. In the case of passenger freight the train length could be reduced by one-third, and in the case of materials by nearly one-half.

J. R. H.

July 12*th*, 1883.

P.S.—Since the above was written, Vol. VIII. (Occasional Papers Series) of the *R. E. Professional Papers* has appeared from the press, containing Colonel Macquay's treatise upon the whole subject of rail appliances for military purposes, but the present notes may hardly be viewed as a repetition of matter, although, in one respect, going over the same ground. It is satisfactory to notice that, from a different field of observation to that in which the present contributor has been employed, the same conclusion has been arrived at respecting the gauge of rail best suited to the rôle of temporary lines. J. R. H.

PAPER VIII.

REPORT ON THE FALL OF THE CHIMNEY AT THE RIPLEY MILLS, BRADFORD, ON THE 28TH DECEMBER, 1882.

BY LIEUT.-COL. H. C. SEDDON, R.E.

(Communicated by the Secretary of State.)

CONSTRUCTION OF CHIMNEY.

THIS chimney, which was built of stone, and about 85 yards high from the top to the foundations—about 10 ft. below ground level—was erected between May, 1862, and November, 1863, under a contract between the late Sir H. W. Ripley and the firm of John Moulson & Sons, builders. The contract was to build an 85-yard octagon stone chimney, with a 9-ft. internal flue, and 24 ft. square at base, similar in every respect to a 60-yard chimney just completed by the same firm at the Ripley Dye Works. Although at that time it was considered an exceptionally high chimney to build, its design was simply a repetition, on a larger scale, of other stone chimneys common to that part of the country.

No professional advice appears to have been taken; and although certain plans, got out for Sir H. W. Ripley by a firm of architects (Messrs. Andrews & Delaunay), were produced to the Court, they did not represent the chimney as actually built.

According to the evidence laid before the Court, the late Sir H. W. Ripley acted throughout as his own architect, employing a clerk of works, responsible solely to himself, to supervise the work.

FOUNDATIONS OF CHIMNEY.

The site selected for the chimney was immediately over a filled-up coal pit, which had been used in getting the coal from a seam known as the 'better bed coal,' about 30 inches thick, and at a depth of about 18 yards from the surface.

The excavation for the foundations was 30 ft. × 30 ft. × 14 ft. deep, through clay, down to hard dark shale which overlies the coal. From the bottom of this excavation, the old coal-pit, which was either 8 ft. × 6 ft., or 6 ft. circular (according to different witnesses), was opened up, and round it were sunk four more circular 6-ft. shafts down to the rock seating of the coal; the old headings were then walled up by packing with dry rubbish, wedged tight to roof and sides with oak wedges, for a radial distance of about 6 yards from the centre of the old pit.

These five shafts were then filled up, from the coal seating to the foundation level, about 15 yards, with lime concrete, thrown in in a sufficiently liquid state to find its own level. A bed of lime concrete, 30 ft. × 30 ft. × 2 ft. 6 in., was then laid at the bottom of the excavation, and on this two courses of 12-in. ragstone footings (no stone under 40 ft. super), the bottom course 28 ft. × 28 ft., and the top course 26 ft. × 26 ft.

Remarks on Foundations.

I had the chimney base bared down to the ragstone foundations, which, though they had never been brought to a level face, appeared to be perfectly sound and undisturbed, exhibiting, practically, no signs of settlement; for on levelling the quoins immediately above the foundations, a difference of level of only $\frac{3}{4}$ in. could be detected. This might have been due to a little want of care in the original setting out, but in any case it would hardly have thrown the top of the chimney 8 inches out of plumb, and could therefore have had nothing to do with its fall.

This being the case, it was unnecessary to go lower down, and to examine the concrete below the ragstone foundations.

At the same time the foundations prepared for carrying the chimney, the total weight of which may be taken as at least 3,600 tons, might be reasonably suspected to have been at fault, although, even if they had yielded at any time, their ultimate condition was evidently not the cause of the accident.

It would be natural to suppose that the ground round an old coal pit might be more or less disturbed, and its condition would not be improved by sinking four more shafts close around it, whilst the common lime concrete piers, formed by filling up these five shafts, could not be relied on to carry a weight which amounted to about $22\frac{1}{2}$

tons per foot super, even when uniformly distributed over them, and to much more when the shaft was acted on by heavy winds.

The use of furnace ashes in the concrete no doubt greatly improved the feeble setting properties of the lime employed; but the very liquid state in which it was thrown in would allow the water to drain out of it into the old coal workings below, carrying away much of the lime from the bases of the concrete piers.

There is always a great risk in building over old coal workings, however well packed they may be, and in the case of so weighty and lofty a structure, standing on so small a base, the results of any failure in which would entail most serious consequences, the right course would have been to have carried the entire structure down to the rock seating of the coal.

That the foundations were not found to be at fault was probably due more to the soundness of the shale below than to the support of the concrete piers.

Chimney Shaft.

The base of the shaft, as erected, was a square of 24-ft. sides, with the angles cut off so as to bring it to an irregular octagon, with four long faces of about $15\frac{1}{2}$ feet, and four angle faces of about 6 feet each; at the ground line, about 10 feet above the base, it was brought to a regular octagon, and so continued to the top.

Two flues ran into the base of the shaft; that on the east side was 6 feet from floor to crown of arch and $5\frac{1}{4}$ feet wide, whilst that on the west side was 7 feet from floor to crown of arch and $6\frac{1}{2}$ feet wide.

The chimney flue was 9 feet 8 inches diameter at the base, working into 9 feet diameter a little above the midfeather, which was 10 feet high; from thence to the top it was a 9-ft. flue.

The shaft itself, which had an external face-batter of about $\frac{7}{8}$ths of an inch to a yard, was constructed as follows, up to 30 feet from the base:

1st. An independent inner 9-in. ring of firebricks, built with one header course to every three stretcher courses, and laid in fine riddled lime mortar.

2nd. A $9\frac{1}{2}$-in. ring of red bricks, consisting entirely of header courses (as far as could be seen, for there was only the lower 20 feet left standing) laid in fine riddled lime mortar, and separated from the inner firebrick lining by a 6-in. air space.

3rd. Filling, or backing, of common rough rubble work, laid and grouted in common backing mortar, the lime being unriddled.

4th. An outer case of dressed wallstones, 6 inches to 7 inches deep on face, averaging about 6 inches on width of bed, and laid in fine riddled mortar.

At a height of 30 feet from the foundations, 19 inches of solid red brickwork, resting on the top of the firebrick and red brick linings below, was carried up to the 38 yards' level, whence it was continued, $14\frac{1}{2}$ in. thick, up to a necking at the 74 yards' level, from which point the rubble backing was omitted, and the shaft was continued in solid brickwork, with the wallstone facing, up to the seat of the ornamental stone capping. This was solidly put together with iron cramps, and apparently had no great projection, besides being shaped so as not to offer much resistance to the wind.

From about the 40 yards' level the same mortar was used in the rubble backing as in the outer and inner faces of the shaft. Eight through bond stones, one on each of the octagon faces, and of the same thickness as the outer wallstones, were specified to be inserted at every 3 feet in height, extending from the outer face right through the rubble backing and half way into the inner brick lining. It was stated that more than the specified number were put in.

When the chimney had reached a height of over 10 yards, Sir H. W. Ripley determined to ornament the shaft by sinking circular and long panels, about 5 inches deep, in each face of the octagon. Accordingly, commencing at a height of about 15 yards from the ground level, four rings of circular, alternating with three of long panels, were constructed on the outer face of the shaft.

The building of the shaft commenced in July, 1862, and went on till about the middle of December, when, frost coming on, it was covered up, its height being then about 40 yards.

Work was begun again on the 28th February, 1863, and was again stopped on the 8th June, when just over 70 yards high, the chimney being found to be out of plumb about 3 feet at the top, though said to have been plumb when left the evening before.

A surveyor was at once sent for, to ascertain accurately the lean of the shaft, and the results of his observations, as shown by drawings produced at the inquest, indicate that the lean was from the foundations, which appears to have been the general impression amongst the men employed on the work, owing to its having apparently gone out of plumb in the course of a single night.

At the same time, the description given to the Court by the foreman of masons was: 'It was all right when we left at night . . . When we came to look at it again it was *bulged out one side and hollow on the other.*

Again, another mason, who went to work during the straightening process about to be described, says in his evidence: 'It seemed to get out of plumb *about* 18 *yards up the chimney.*'

Straightening Operations.

After the surveyor had fixed the extent and direction of the lean, a chimney straightener, of the name of Woodman (now dead), was sent for from Manchester.

This man, who is said to have doctored a great many brick chimneys, but is not supposed to have been previously engaged on a stone chimney, straightened the shaft by cutting a slice out of it, a little more than half way round, on the opposite side to the lean, and at a height of about 17 yards from the ground, of the same thickness as one of the courses of the facing stones (6 inches to 7 inches), replacing it by a course of flat bond stones passed half way through from both the inside and outside of the shaft. This course was half an inch thinner than the course of wallstones removed, the reduced thickness being made up by thin iron wedges, which, when finally drawn, let the mass above them down on to the bond stones below.

This operation brought the top of the shaft back about 18 inches out of the 3 feet, but not altogether in the direction desired.

Accordingly another similar cut was made, about 3 feet higher up, which brought the shaft plumb.

It is important to mention here that in cutting out these two slices the external quoin stones were purposely left in, to prevent the mass above coming over too suddenly, the result being that the outer casing was cracked and broken above and below those quoins for a considerable distance. The damaged portions of the outer casing were afterwards removed and made good, but *without disturbing the backing by attempting to bond the new face work to it.*

The operation of drawing the iron wedges, which took from three to six days for each cut, was thus described by one of the masons employed on it:

'We had to use big hammers to move them, knocking the wedges from side to side. When we moved the wedges a bit, it seemed as if men were striking a 40 HP. boiler. That was the throughs breaking.'

The sound so described is not a single report, but a succession of reports, dying away gradually.

Another mason employed upon the straightening said: 'I heard noises like the discharge of pistols.'

Nothing was done to the side of the shaft opposite to the cuts, though one of the witnesses stated that the joints on the opposite side of the shaft to the cut showed signs of opening. After the straightening, the chimney was gone on with at once and completed.

Remarks on the Straightening.

Notwithstanding the surveyor's drawings and the general opinion expressed by the men employed on the work, that the cause of the chimney leaning was a sudden giving of the foundations during the night of the 7th June, the evidence of a member of the firm employed in erecting it, and the description already quoted of the appearance of the shaft, given by two of the masons, together with the fact that the spot selected for cutting into it was 17 to 18 yards above the ground level, all seem to point to the conclusion that the leaning over was not from the foundations, but rather from some distance above them.

All the witnesses, however, agreed in stating that the top of the shaft was 3 feet out of plumb, whilst the surveyor's plans confirm their evidence. Taking this to be the case, and also that the course replaced at each cut was only $\frac{1}{2}$ inch thinner than that taken out, about which there was no difference of opinion, it is clear that there must have been considerable yielding somewhere for the shaft to have become plumb, as it would have required nearly 3 inches to be taken out, at the level of the cuts, to have brought the top of the shaft back a distance of 3 feet. Bearing this in mind, it is quite possible that the foundations may have been partly at fault, and that on the weight coming over, they yielded slightly in the opposite direction, thus bringing them nearly level again, as they were found to be on the removal of the base of the shaft.

The effect of making a cut 6 inches to 7 inches deep through the rough rubble hearting of the chimney, inserting the bonds and wedges meeting half way through, and then drawing the wedges and letting the rubble hearting above down on to the bond stones, was simply to break the latter like biscuits; whilst, as the upper part of the shaft, weighing about 2,200 tons, gradually took its new bearing, the hearting would be shaken, and numbers of the throughs would break up with the loud reports described by the witnesses. Again, by leaving in the quoins to take the first shock of the weight as it came over, all bond between the outer casing and the hearting was destroyed for some distance both above and below the cuts.

The opening of the joints on one side of the shaft was but the natural consequence of taking a slice out of the other side, and in regular coursed work such as a brick chimney, this could have been remedied by wedging up, or removing a course of bricks and turning them on edge; but nothing of the kind being done in this case, the upper shaft, about 2,200 tons weight, would in every wind be liable to rock with disruptive effect, surely, however slowly, destroying all cohesion in the masonry at and about that level, and especially in the unfortunate slice lying between the upper and the lower cuts.

Subsequent History and Fall of Chimney.

In 1866, three years after its completion, the same firm of John Moulson & Sons were employed to take down some of the outer casing (at and about the level of the two cuts) which had become loose, showing cracks, bulges, and broken stones. The witness, William Moulson, stated: 'I was of opinion that the cracks had been caused by the tilting of the chimney, which had had a tendency to make the outer case bulge at the height of the cutting. Of course, the throughs were broken. We took a lot of the outer casing off, including the eyes (lowest circular panels) and replaced it with good stone. This occupied about seven weeks, involving an outlay of about £96.'

Both he and his foreman stated that the hearting, behind the outer casing removed, appeared to be then quite sound, and the chimney itself to be perfectly straight and in the same condition as when completed. It was not till about five years ago that the same witness noticed it to be at all out of plumb, whilst other witnesses spoke to having seen slight cracks for some years back, but chiefly along the joints, which were pointed up some four or five years ago. Nothing particular, however, appears to have been noticed until about two years ago, when the steward, who had been in charge of that property for nine or ten years, drew Sir H. W. Ripley's attention to a crack which appeared to be about two yards long and $\frac{1}{2}$ inch wide at the S.E. angle, one of those previously damaged, just below the lower cut; and a year later he pointed out a second crack which had appeared on the S.E. face, starting about seven yards from the ground, running straight up for three or four yards, and then following the joints irregularly. The crack at the S.E. angle seemed to be about the same then as when first noticed. Sir H. W. Ripley did not appear to think much of these cracks, probably merely waiting till it should become necessary to repeat the repairs carried out some sixteen years before. In less than a year after this, on the 9th November, 1882, Sir H. W. Ripley died. About the beginning of December the steward fancied that the crack at the S.E. angle looked bigger, and on the morning of the 20th December, in passing through the yard after a heavy snow storm, he noticed that the wallstones of the outer casing, between the two cracks, were so bulged that he could see daylight behind them.

The chimney had been leaning a little to the S.E., the direction of its ultimate fall, for some time; sufficiently, at last, to lose its face batter, though not to overhang.

Mr. Humphreys, a builder, was at once sent for, and from that time until its fall men were stationed in the yard, and afterwards barriers were put up to prevent anyone approaching the chimney for fear of their being injured by the falling of any of the wallstones of the outer casing.

That same afternoon chimney ladders were fixed against the shaft, and the next morning an examination was made of the bulge by Humphreys and Miles Moulson, one of the masons who had worked at the straightening; and again in the afternoon in the presence of Mr. Andrews (successor to the firm of Andrews & Delaunay), who held the original plans connected with the chimney, and had designed several well-known chimneys in that part of the country.

The conclusion come to was that the chimney appeared to be safe, and that the bulging of the outer casing was no doubt due to the damage done to it in the straightening operations; at any rate, that the loose portions must be taken down before the hearting behind it could be examined; and that, if it was found to be sound, all that would require to be done would be to renew the damaged facing. Mr. Humphreys, to whose firm the work was entrusted, states: 'I went up (the shaft) to look, on the Thursday before Christmas Day. I then found a portion of the outer face ready for tumbling, but the inner case, from what I saw, was sound enough—in good condition.'

The question of examining the interior of the chimney was discussed, but apparently postponed, under the idea that the condition of the hearting could not be seen from the inside on account of the inner brick lining; also that an internal examination would be unnecessary should the hearting, as revealed on the removal of the outer casing, prove to be sound. On Saturday, 23rd December, work was begun by placing a plank, from the top of a ladder, behind the bulge on the east face, and pulling it down; an attempt was also made to pull down another bulge found on the S.E. face, but without success, and it was therefore left to be taken down from the scaffolding when erected.

The work of erecting the scaffolding was proceeded with on Sunday, Christmas Day, and Tuesday. On Wednesday morning no work was done on account of heavy wind and rain. On that morning, however, the bulge on the east face, which they failed to pull down on the

Saturday, fell of its own accord, breaking down part of the scaffold and the ladders.

Wednesday afternoon was spent in procuring fresh scaffolding and ladders, which, not being ready the first thing on Thursday morning, caused the men to be late at their work, and so to escape the fall of the chimney, which occurred a few minutes after 8 A.M. On Wednesday night and Thursday morning the wind was very high, and early in the morning some more of the outer casing fell, and small portions, as described by some witnesses, no doubt came away from time to time after the pulling down of the bulge on the east face, naturally alarming the women and children in the surrounding mills.

According to the evidence of the only witnesses who clearly saw the fall of the chimney—during a heavy gust of wind it burst out suddenly, at a considerable height above the ground (one of the men at the barriers in the yard says 'just above the top of the scaffolding'), then the upper portion just settled down vertically, and finally seemed to turn slightly on its heel and fall over to the E.S.E., cutting down the Newland Mill, a four-storeyed building occupied by three different firms of worsted spinners and wool-top makers.

Besides levelling the greater portion of this mill to the ground, about 54 lives were sacrificed, in addition to the injured. Had the chimney fallen but a few minutes sooner, the loss of life would have been far greater; fortunately, it happened when most of the hands had left for breakfast.

Results of Inspecting the Ruins.

I first saw the ruins some five days after the disaster, by which time most of the dead bodies had been recovered, and the *débris* had been cleared away from the actual site of the fallen mill; the yard however was filled with the wreck of the chimney, to a depth of about 18 feet, completely covering up the portion of the base of the chimney still left standing. I was frequently on the ground during the removal of the *débris* round the base of the shaft, and carefully inspected the latter as it was first cleared out down to the underground flues and then taken down, piece by piece, to the ragstone foundations, which, as already stated, were found to be undisturbed and practically level.

The *débris* was heaped up round the broken base of the shaft, just as would have occurred had it burst out, as described, at some distance up, and then the upper portion, crushing and being crushed, settled down vertically and finally toppled over.

The cap of the chimney lay in a cellar beneath the ruined mill, at a distance of about 120 feet from the base of the shaft, giving some idea of the length of the upper portion which finally fell across the mill.

The *débris* consisted chiefly of loose stones, of all shapes and sizes, from the backing and powdered mortar, mixed up with loose bricks from the inner lining and wallstones from the outer facing; some of the latter were firmly cemented together, and in many cases stained on the backs and in the joints with soot, which must have come through cracks in the backing. Whatever throughs there might have been were evidently broken up, as very few were found entire.

Of the backing very few fragments remained so large as a cubic yard, and even these were ready to tumble to pieces, and in no case did I find any portions of the backing and the outer casing holding together.

The backing mortar, where not reduced to powder, was full of large lumps of unslaked lime, and seemed to have been run in profusely, being often from 7 inches to 14 inches thick, one mass seen being quite a foot cube in bulk. In fact, as acknowledged by one of the witnesses, the rubble backing was regarded as mere filling in between the inner and outer casings, and was composed of the commonest materials used. An exception, however, must be made with respect to the backing below the ground level, which was very sound and solid, requiring to be got out with picks and crowbars; the same mortar had been used as above ground (a pure lime mixed with furnace ashes and sand), but the stones were large and flat bedded, and the work not being exposed to vibration, as above ground, the mortar had had a better chance of setting hard.

The stones in the outer casing were much too shallow on bed, and, having no proper connection with the backing, were of little use except as regards appearance. The bricks used in the interior of the chimney were very good, but the condition of the inner firebrick lining in conjunction with the bulging of the outer skin would, had it been inspected, have shown that some serious settlement had been going on in the backing. It was very badly buckled and rent, the cracks being evidently of long standing.

Opinion on Causes of Failure and Remarks.

The failure of this chimney was undoubtedly due to the operation of straightening. The only wonder is that it survived that operation for twenty years. One cut would have been serious enough, but the second was fatal to the slice of masonry between the two cuts. The weight of the shaft above (at least 2,200 tons, giving a uniform pressure of nearly seven tons per foot super) rocking in every wind on this weak spot, slowly but surely disintegrated the masonry; the loose rubble backing in yielding threw the weight on the damaged outer casing and the inner brick lining, which latter stood on two independent single brick cylinders 30 feet high, the inner one of firebrick exposed to all the heat of the ascending gases, and the other of red brick laid without any stretchers, at any rate for the greater part of its height.

The leaning of a chimney and cracks in the shaft would not be sufficient of themselves to cause any apprehensions of immediate danger in a district where the majority of the chimneys are more or less cracked, and many are considerably out of plumb; but, as it happened, those who examined this chimney were misled, by a knowledge of its previous history, into thinking that the rapid development of the cracks and bulges was merely due to the vibration of the chimney in the wind loosening the old portions of the outer casing, which had been built up after the straightening without being tied into the backing, and which had again become loose and undergone similar repairs about sixteen years before.

The chimney was, in reality, daily resting more and more on its outer skin, to remove which, as decided, was no doubt a fatal error. Before, however, this could be done, piece after piece of the outer shell was pinched out, and the rocking of the shaft in the wind on the Wednesday and Thursday morning completed the destruction of the chimney. A heavy gust came, and the damaged backing, having lost the little tie previously afforded by the outer casing, burst out and all was over.

It is easy to be wise after gaining experience, but the history of this chimney is so exceptional that I doubt if anyone would have anticipated any immediate danger. The cutting straight of brick chimneys is an operation of common occurrence, but I am not aware of any stone chimney, except this one and another close by belonging to Messrs. Sugden & Brigg's Works, having been so treated. I unhesitatingly say that it was an operation which ought never to have been performed. The design of the chimney was radically bad in almost every particular, and although the actual cause of its falling when it did was the damage done to it in straightening, I feel certain that, even without that operation, it could only have had a limited life; and, unless taken down in time, it would certainly have fallen some day or other.

The system of constructing chimney or any other walls to carry heavy weights of three or four different parts, each too weak in itself, and yet so put together that they cannot possibly work in unison, cannot be too strongly condemned; whilst the necessity in large chimneys for the fire-brick lining being perfectly independent of the structural part of the shaft is now universally recognised. The fall of this chimney ought to be a warning in future to anyone who, dispensing with proper professional advice, takes upon himself the responsibility of carrying out works upon the safety of which the lives of so many may depend. Here we have a self-constituted architect and engineer, with a thoroughly bad design to begin with for an 85-yard chimney, in which the uniformly distributed pressure on the masonry at the base of the shaft would amount to over 9 tons per foot super, first deciding, after getting about 10 yards above the ground line, to carry the shaft up to 100 instead of 85 yards, with the idea of making it look lighter (this was abandoned after the failure at 70 yards), and next weakening the structure considerably by inserting recessed panels all the way up to ornament the faces, and that in spite of the advice of his builders to the contrary.

It may not be out of place here to point out that there is a limit to the useful height of a chimney as regards draught; whilst the increase of height is frequently more than counterbalanced by the losses due to sudden changes of direction in the underground flues, and their want of gradual easing into the chimney, as well as by the unnecessary admission of cold air into the interior of the chimney.

Looking to the possibility of there being other factory chimneys in a dangerous condition, as well as to the evidence of the Bradford Borough Surveyor as to the difficulty of getting to know of such cases, whilst he has no power to inspect such structures without some grounds to go upon, it is worthy of consideration whether the Factory Inspectors might not be empowered to make inquiries on this subject, and to report any cases which may come to their knowledge.

H. C. SEDDON,
Lieut.-Colonel R.E.

March 13, 1883.

R.E. Institute, Chatham,
20th March, 1883.

To the Under Secretary of State,
Home Department.

Sir,—Referring to my Report on the fall of the chimney at Bradford, already forwarded, I omitted to mention a point which, I think, ought to be brought to the notice of the Home Secretary, namely, that neither in Bradford nor in Leeds are there any building regulations analogous to those contained in the Metropolitan Building Act. Beyond fixing a minimum height for factory chimneys, there are no regulations to ensure their safe construction, or that of any other buildings.

Some such regulations seem to be required in these large commercial centres; for instance, the means of egress from lofty factories, crowded with operatives, are often so narrow and limited that the results of a fire would be terrible to contemplate.

That the safety of those who are crowded together in some of these factories is often not sufficiently consulted was evident from the existence, very near the site of the disaster, of another chimney, about 103 yards high, bending over considerably at the top—so much so, that the owners, after what had occurred at the Ripley Mills, decided to lower it 100 feet; which work had just begun when I left Bradford. The foundations of this chimney, I ascertained, had been carried down to the rock seating of the old coal seam below, and the whole structure had been far better put together than the chimney that fell. The general impression, however, that its appearance conveyed to the mind, from a little distance, was certainly one of insecurity, whilst it seemed to have been watched anxiously by the people about during any heavy gales; at the same time, when viewed close by, it looked solid and safe. Such a lofty chimney, however, rocks very considerably in heavy winds, and although the coincidence might not have occurred in 100 years, still an exceptionally heavy gust, just happening to catch it when full on the swing, might have caused a terrible accident. The question is whether such a doubtful structure, surrounded by factories full of operatives, ought to have been allowed to remain standing until the owners, warned by the havoc and loss of life brought about by the fall of a neighbouring chimney, thought it best to put an end to the risk.

I have the honor to be, Sir,
Your obedient servant,
H. C. Seddon, Lieut.-Col. R.E.

PAPER X.

THE 'FORTRESS WAR GAME.'

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

In few branches of the Art of War have modern weapons brought about greater changes than in the attack and defence of fortresses. The broad principles of strategy scarcely vary; it is their aspects and modes of application alone which alter with the times. But fortresses have undergone little less than a vital change of principle, to which the attack will have to conform. In one sense change favours the latter. Fortresses, like navies, modernize slowly, and both must always be a little behind the time. Fortification received, however, a great impetus after 1871, and in a new Franco-German war the attack and defence will meet on a fairer level than at Strasburg.

The great change of principle which has come over fortification is the decentralisation of the defence, or its dissemination over numerous strong points, instead of within one uniformly strong ring. This change has entailed many others, and it has left us in some uncertainty, not so much how our forts should be built, as how their defence should be conducted. There are many points which the theorist cannot settle, and which must remain undecided till they are brought to the rough test of war. But one thing is certain. The defence of to-day requires far more genius than that of Wellington's time, and genius, moreover, of a much higher order. Putting moral qualities aside as counting as much or more now than ever before, the commandant of a Peninsular fortress needed a brain fertile in expedient. The commandant of a besieged Metz needs to be a general of the very highest order. He has a great area to defend. His chain of forts presents gaps which his engineering and tactical

* The name is a difficulty. We have naturalized 'Kriegsspiel' boldly and unnecessarily, but 'Festungs' as a prefix would perhaps be too much to borrow, while a compound of English and German is clearly not to be thought of. 'Siege Game' might possibly recommend itself.

genius must enable him to make good. He commands an army, not a garrison. His possible courses of action are numerous, and his earliest decisions of vast importance. He should be a strategist of high order.

But while the conduct of the defence of to-day makes new demands on the General, it also requires more from the Engineer. The latter needs a severer course of training, and precisely that kind of training which is difficult to obtain. The great value of Kriegsspiel is that it entails thought of a special kind, and to enforce such thought, over a solitary study of a map, needs an amount of self-discipline which few possess. And, moreover, it enables the mind to form some conception of the time required for carrying out military combinations. Further, by introducing a spirit of competition and an element of uncertainty, it at the same time quickens the interest and tends to engender a power of rapid decision. There is no reason why there should not be a Fortress War Game, and such a game has, in fact, been played for some years in Germany, with all the admirable earnestness which Germans are able to bring to bear upon everything military.

During a recent visit to Berlin the writer happened to meet with an excellent little work on fortress warfare, the author of which, in his preface, states that the ideas he propounds are 'the results of a study of military history, and of the theoretical experience gained in the Fortress War Game.' This game does not appear to be sufficiently known in England, and no full details, embodying a complete set of rules like those of Kriegsspiel, have at present come to hand. The following account, taken from a pamphlet* published in 1872, will, however, serve to give a fair general idea of the scope of the game. The rules, and probably the symbols used, would require to be modified to suit English conditions. In view of the great importance of the subject of fortress warfare, and the difficulty of doing justice to it by ordinary modes of instruction, it seems most desirable that the Fortress War Game should be taken in hand by a joint Royal Artillery and Royal Engineer Committee, who would give it an English dress. Once established, it would take an important place in the training of young officers at Chatham. The game would, however, be useful over a far wider field than this. By its aid many ideas now floating in turbid solution would tend to settle down, while many new ones would unquestionably present themselves for consideration and discussion. An attack and defence of the Plymouth land position, or of the new

* Directiven für das Festungskriegs-Spiel, auf dienstliche Veranlassung bearbeitet von Neumann, Major à la suite des Rheinischen Feld-Artillerie-Regiments No. 8, und Lehrer der Artillerie-Schiess-Schule.

line of works at Chatham, carried on by able and well-matched antagonists, would elucidate much which is anything but clear at present. Under such circumstances it might be expected that a new light would be thrown on the whole question of the employment of the artillery of the defence. Objections to the game there must of course be, in that it ignores the human factor. But Kriegsspiel has none the less been recognised as a powerful educational instrument, and the fortress game is perhaps less unreal. On the whole, it is probable that the result of a contest between guns of given natures, engaged under given conditions, is more likely to be rightly adjudged than that of the conflict of men. In any case, the conduct of the siege and of the defence of a fortress will require organisation and method in a high degree, and both may be learned, in some measure, from the game. If the latter is successful merely in bringing home to our minds the difficulty of the tasks we may be called upon to fulfil, it will be none the less worthy of our serious consideration.

Objects of the Game.

'In the Fortress War Game the principles of fortress warfare are reduced to a practical form by two opposing parties using a map and suitable blocks. It is thus possible to represent the conditions of the attack and defence with as close an approach as possible to the reality, and to obtain the best kind of teaching on the subject. Instruction as to the proper mode of employing artillery in the attack and defence may be considered as a main feature of the game.'

Requirements.

1. Adequate data as to the fortress to be attacked and defended, including—
   - *a.* Maps and plans.
   - *b.* Drawings and sketches of essential details which the plans may not show; *e.g.* important profiles, &c.
   - *c.* Written descriptions.
2. Blocks of type-metal or lead, to indicate guns, batteries, saps, &c. (*See* Plates I.-IV.)
3. Blocks indicating field troops of all arms. Those used in Kriegsspiel will be suitable.
4. Wooden scales covered with paper—reading on one side distances, and on the other slopes corresponding to contours.
5. Compasses.

6. Light iron and copper wire in pieces of suitable length to mark shooting lines.
7. A pair of dice.
8. Some light wands for pointing.
9. Forceps for handling the smaller blocks.

The maps and plans should show not only the ring of the defence, but also the interior of the position, as this may have an important bearing on the attack and defence. It is particularly important that the communications and bombproofs should be indicated.

The scale of the map should be so large that the pieces required for the game are not too small and inconspicuous. A scale of $\frac{1}{2500}$ is suitable, but will usually be manageable only in the case of small fortresses. For large places with outlying chains of forts, a scale of $\frac{1}{5000}$ will have to be adopted.

It is desirable that the map be coloured in order to make the surface features of the ground more clear.

The map must be contoured, and it may be advisable that portions of the ground should be hill-shaded to make the accidentation more conspicuous. Even thus, a correct and rapid understanding of the ground is often difficult, and in some cases the employment of relief maps or models would be advantageous.

The principal map must show the terrain of the fortress, at least as far as the first artillery position of the attack. For the more distant ground involved in the operations of the investment, sites of parks, &c., the ordinary maps will often serve.

The maps and plans should be cut into squares and mounted on millboard as for Kriegsspiel. The side of the squares would be a round number of metres—500 or 1,000, according to the scale.

Objects or features, whose existence is to be taken as unknown, can either be omitted in the plan or covered over as long as may be desirable.

Detail drawings, sketches, &c., will only be needed when the dimensions which can be taken from them are of importance to the game, and provided that it is supposed that they could have been obtained in some way or other. Descriptions are to be used to explain matters necessary to the game, but not made clear in the maps, plans, detail drawings, and sketches. Descriptions can be more or less full, or may be only oral communications. Incorrect information may even be given, which may afterwards be corrected by degrees.

By such information many modifications of the game are rendered possible, both in its general course and at special periods.

Plates I.-IV. show the blocks employed to represent guns, batteries, &c., on the scale of $\frac{1}{2500}$. For the $\frac{1}{5000}$ scale, smaller blocks can be used; but in their absence, the larger ones can be used without much disadvantage. The symbols for particular objects cannot always correspond with the map in scale, especially where the latter is small. They must, however, be made as clear and simple as possible, and bright colours should be used.

Field troops are represented as in Kriegsspiel, but it should be remembered that the blocks for the latter are designed for a $\frac{1}{8000}$ scale. In order to mark shooting lines, the defence uses iron and the attack copper wires, or *vice versâ*. At particular moments when it is desired to show the lines of fire of the attack or defence these wires can also be used. Coloured wires can be employed to designate different kinds of fire.

Personnel.

To supervise the game, an experienced officer is required as umpire. He makes all arrangements, lays down for both sides the conditions which are to be observed, and which do not arise as necessary consequences of the game, while he decides all issues, occasionally having resort to a throw of the dice.

When the game is played on a large scale, it is desirable that the umpire-in-chief should have two assistants, to whom he delegates some of his functions, retaining the powers of final decision. One assistant umpire takes charge of the attack and the other of the defence. If a question presents itself for decision, the assistants have first to consider it from both points of view, and to endeavour to arrive at an agreement, using the dice if necessary. Should no agreement be obtained, or if the decision arrived at by the assistants appears incorrect to the chief umpire, the latter gives his verdict, from which there is no appeal.

If the game lasts a long time, with considerable breaks intervening, it is necessary to keep a journal, and to appoint an officer for that duty.

The rest of the players are divided into two groups, for attack and defence. In making the division, it is necessary that each group should contain an officer fully qualified to lead it. This officer determines for his group all matters which do not come within the province of the umpires, details the separate functions of the members of his group, and decides whether they are to commit the special tasks to paper or otherwise. These special tasks, after they have been separately taken in hand, will be worked into the action of the game itself, receiving such modifications as may be necessary.

The minimum number of players is three—an umpire, a defender, and an attacker. The maximum permissible is about twenty, which gives eight for each group, an umpire-in-chief, two assistants, and a record keeper.

It is desirable that particular functions should be allotted to each player, and that on every day of the game the same players should, as far as possible, carry on the same duties.

The following may be taken as an example of the division of labour in the groups:

For the Defence.

One officer in command of the whole, and to work out any special questions which may arise.

One or more officers as section commanders.

One officer for various internal arrangements, such as observation, telegraphic communication, precautions against fire, hospital erections, interments, &c.

One or more officers for the defence of the terrain of the fortress.

A single officer may have to undertake several of the above duties.

For the Attack.

One officer in command of the whole, and to work out any special questions which may arise.

One officer to ascertain the artillery material required for the siege; to arrange and manage the artillery parks, &c.

One officer to carry on the fight in front of the fortress, and the investment.

One officer to take charge of the first artillery position, the fixing of the sites of the batteries, the calculation of working parties for them, and all matters relating to their construction.

One officer to direct the fire of individual batteries and to fix its direction.

One officer for the later batteries.

One officer for the special functions of the batteries, breaching, demolition, &c.

In the attack, as in the defence, one officer may have to undertake several of the above duties.

Conduct of the Game.

The carrying out of the game must in every case be made to correspond with the particular circumstances. Special consideration is to be given to the abilities of the players, their number, the time available, and the particular end to be aimed at.

Generally speaking, the discussion of particular phases should be as thorough as possible, in order to bring the really important features into sufficient prominence. This demands, however (especially where the knowledge of the game is only slight), so much time that it is not always possible to carry out the whole course of the attack or of the defence with uniform thoroughness. It may thus be necessary in the game itself to take individual portions at specially important periods into full consideration; and in the groups to deal with the separate problems as fully as time allows, bringing their results only into the action of the game.

When special ideas present themselves, as in Kriegsspiel, a full treatment may be altogether dispensed with, or it may be sometimes sufficient to treat a similar case in the general idea. In other cases, however, the outcome only of such special ideas may be worked into the game, having regard to the available time. When circumstances repeat themselves, or in cases where the standpoint of the players allows, it will often suffice to carry out certain measures once, and later on only to take their results into calculation.

In many cases, particularly when the players have but little experience, it will be desirable to open the game with a general discussion on the various circumstances, so as to clear matters up and render the study more valuable. Then would follow the detailing of the officers for the various duties, while the umpire fixes such limiting conditions as he considers necessary, both for the attack and the defence.

On these data the players set to work, and after the special preparatory tasks have been worked out in the respective groups, the leaders bring the results into the action of the game. The latter cannot begin until the materials brought together in the special tasks are made public to such an extent as, in the judgment of the umpire, may be required. All special matters, with respect to which either of the opponents could not obtain information, would obviously be excluded during the course of the game; the umpire can, from time to time, give information to either side in any form he may consider proper. Such information may, under some circumstances, be of an uncertain kind, or even false.

The journal would be commenced with the game, and would contain the general idea, with a statement of the strength and resources of both sides. With regard to the course of the game itself, the following matters should be particularly noted :—

Date. Conditions assumed with respect to the weather on such days as the latter would exert an influence upon the operations of the attack or defence. Thus it should be stated whether the day is bright, cloudy, or foggy, dry or rainy; whether the night is light or dark, the moon's phase being taken from the almanack. The direction and strength of the wind should be given.

If the operations are supposed to be carried on into winter, the temperature should be given each day, so that account may be taken of its influence. The length of the day and night would be fixed by the period assumed for the operation.

Besides such matters as these, which the umpire settles, the journal should record all important measures taken by either side, and their results. The more comprehensive measures would be added as they arrived at a realisation.

The above is evidently incomplete as a course of directions for playing the game. It will serve, however, to give some idea of what is aimed at, and there would be no great difficulty in laying down a set of rules, and in giving the game a form suited to our conditions, possibly simplifying and narrowing it to some extent. Some of the matters taken into account—the 'Rollbombenvorrichtung' and the 'Wall-Lampe,' for example—may strike one as being almost ridiculously over-minute, but the results of attention to microscopic detail in military affairs have been made sufficiently manifest, and it is only when the sense of proportion is blunted or lost that such attention becomes detrimental.

From the brief and incomplete account which has been given, it will be evident that the Fortress War Game is not a thing to be lightly undertaken, but the value of such a game as a course of mental discipline as well as special training for officers of the ordnance corps will probably be acknowledged.

The valuable fortress manœuvres annually carried out in Germany appear to be impossible in England. We cannot play with men, and it is perhaps all the more necessary for us to play with maps and counters.

G. S. C.

London: *January*, 1884.

TRESS WAR GAME.

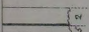
Plate I.

Fortress War Game, Scale (1·2500).

2 m m
"

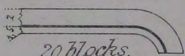
oils on one side only, except
ed on all four long sides.

etc.



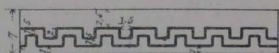
ks of each.

2. Returns.



20 blocks.

4. Double Sap.



h.

6, 5, 4, 3, 2, 1 traverses; 10 blocks of each.

6. Traverses.

a. Ordinary.

newly made

100 blocks.

consolidated.

100 blocks.

b. Hollow.

50 blocks.

PAPER XI.

RECENT ARMOUR PLATE EXPERIMENTS.

By Colonel T. Inglis, C.B., R.E.

The last of my usual notices of Armour Plate trials appeared in Paper XII., vol. iv., 1880, the subject being then brought up to about the middle of that year. In Paper II., vol. vii., 1882, which dealt generally with the subject of armoured defences, and to which a postscript, dated May, 1882, was added, a few matters bearing upon more recent gunnery trials were noticed.

It is now proposed to discuss all known experiments which have not been already reported, and thus to complete the subject to the end of the year 1883.

Trials of Wrought Iron Armour at Meppen, in 1882.

There is only one set of experiments dealing exclusively with wrought iron armour to be noticed in this paper, and that I will dispose of before entering upon others of greater importance. This formed part of a series of trials conducted by Krupp, at Meppen, in March, 1882.

The first target consisted of a sandwich of two 7-inch wrought iron plates bolted together, with 9·8 inches of wood between them. The gun used was the 15-c/m. (5·9 inch) 35 calibre gun, throwing a steel shell weighing 107·3 lbs. In the first round the shell, without a bursting charge, struck with a velocity of 1,705 f.s., and an energy of 2,509 foot tons, and perforated the target with comparative ease, passing afterwards some 1,200 yards up the range. It was slightly set up, but not broken. In the second round a similar shell passed through the same target and was broken up. Both shells hit square with the face of the target. As these shells should, by calculation, only perforate a little more than 11 inches of solid wrought iron, the facility with which they passed through 14 inches of that material, in two thicknesses, must be accounted for by the fact of so large an interval as 10 inches having been allowed between the plates of this target, especially as I believe there was no defect in the plates themselves. It will be seen, on reference to Paper XII., vol. iv., of this series, page 181, that a similar undue success of shot, at Meppen, in 1879, was attributed to a sandwich target having been made with too small an interval for the wood between the armour plates. In the present case the interval was as much too large. Had there been 5 inches of wood between the plates in each case, the resistance of the target would have been very different. It is well to notice these defects and their results, because they quite bear out our experience derived from the original trials of 1868–69, namely, that the value of the plate-upon-plate system depends very largely upon the spaces by which the plates are separated.

The second target used at Meppen, in 1882, consisted of an 8-inch wrought iron plate backed by 10 inches of wood, and a skin of iron plate about 1 inch thick. This was fired at obliquely by the same gun as before, the shell striking at an angle of 55° with the face of the front plate, or 35° from the normal. With the velocity of 1,750 feet per second with which it struck, the shell would have perforated nearly 12 inches of wrought iron, hitting direct. In the oblique direction in which it actually struck the target, the shell had upwards of 12 inches of iron to cut through, so that the complete perforation of the target which it accomplished is somewhat more than it might have been expected to do, especially considering the loss of work generally occasioned by imperfect biting of the shot's point on the face of the armour in oblique hitting.

Proportion of Steel to Iron in Compound Armour.

In speaking, upon former occasions, of the mode of manufacture of compound (steel and iron) armour plates, which have gained so much importance of late, it has been said that the thickness of steel in one of these plates should be between $\frac{1}{4}$ and $\frac{1}{3}$ of its entire thickness. For the further investigation of this point two trials have taken place during the last twelve months. One was made on board the 'Nettle,' at Portsmouth, by the Admiralty, when a 10-inch plate (made by Messrs. Cammell and Co., of Sheffield), composed of half steel and half wrought iron, the iron next to the steel being rather harder than usual, was proved with a 10-inch M.L. service gun, and Palliser shot fired with a charge of 70 lbs. P. powder. The other took place at Shoeburyness, when an 18-inch plate (made by Messrs. Brown and Co., of Sheffield), composed of $\frac{1}{4}$ steel and $\frac{3}{4}$ wrought iron, was proved with a 12-inch B.L. gun of 43 tons, firing a 720-lb. Palliser shot with a charge of 280 lbs. prismatic powder, at a range of 108 yards. (Round 2,374). In the former case it was thought that the results were not sufficiently promising to warrant further trial of the proportions of steel and iron used in the plate. In the latter case there were no indications of such advantage over the ordinary proportions of steel and iron as would justify a change. Thus, after all, the proportion of $\frac{1}{3}$ steel to $\frac{2}{3}$ wrought iron, originally arrived at almost by guesswork, has not yet been improved upon.

The only other change of any importance that has taken place in the manufacture of these plates, consists in the gradual attempt to use harder steel in them. Whereas at first they were made of steel containing from 0·4 to 0·5 per cent. of carbon, a larger proportion, of from 0·7 to 0·8 per cent. has been lately used, with good results as to resistance, and with no apparent loss as to brittleness. The Sheffield manufacturers have now so far extended and improved their plant that they can turn out very large plates of this material.

Italian Experiments in 1882.

In the autumn of 1882 the Italian Government carried on an important experiment at Muggiano, near Spezia, with thick compound and steel plates, with a view to determine which of these kinds of armour should be used on the breastworks enclosing the turrets of ships of the 'Italia' and the 'Lepanto' class.

Three plates were made for the trial; one a compound plate by Messrs. Cammell & Co. of Sheffield, one of the same kind by Messrs. Brown & Co. of Sheffield, and one wholly of steel by Schneider & Co. of the Creusôt Works, France. All three plates were of the same dimensions—namely 10 ft. 10 in. long, 8 ft. 7 in. wide, and 18·898 inches (48 c/m.) thick.

In the Cammell plate the steel was 6 inches thick and contained 0·65 per cent. of carbon. It was made by the process known as Wilson's patent, and adopted for all their plates used at Shoeburyness during the last few years. Brown's plate was made of the same proportions of steel and iron, but the steel contained 0·7 per cent. of carbon. It was made on Ellis's patent exactly as our own plates have been made. The Schneider plate consisted wholly of steel containing 0·45 per cent. of carbon. It is believed to have been made under the hammer, not by rolling, and that its face was hardened in oil, but little beyond this is known of its manufacture.

Each plate was confined in a wrought-iron frame, 33 inches wide, consisting of three thicknesses of 6-inch plate strongly bolted together, but of otherwise very defective construction. The plates were backed by 48 inches of oak, to which the plates were held by mild steel bolts $4\frac{1}{2}$ inches in diameter, screwed a short depth into their backs. The English plates were held by six bolts each, the Schneider plate by twenty-six. The targets were supported by timber struts in rear, and the iron frames enclosing the plates were held up by long props in front.

The gun used was one of the 17·72-inch M.L. guns of 100 tons, made by Sir W. Armstrong & Co. for the 'Duilio' class of ships. The first practice took place on November 16th, 1882. One round was first fired at each plate with the following charge, namely, a shot of chilled cast iron (Gregorini) weighing 2,000 lbs., with heads struck to a radius of $1\frac{1}{3}$ diameter; the firing charge being 328·5 lbs. of Fossano Progressive powder. The hits were all in the lower left hand corners of the plates.

The results were briefly as follows: Cammell's plate: striking velocity of shot 1,219 f.s., striking energy 20,600 foot tons. Corner of plate broken off, iron frame gave way at the angles, fine radial and circumferential cracks on face of plate. Shot broke up, mostly in small pieces; depth of indent not ascertainable.

Brown's plate: striking velocity of shot 1,222 f.s., striking energy 20,700 foot tons. Plate cracked but very little, one long thin crack developed at some distance from the shot mark. Iron frame gave way at angle nearest shot mark; shot broke up rather more than in former round; depth of indent about 8 inches.

Schneider's plate: striking velocity of shot 1,232 f.s., striking energy 21,000 foot tons. No cracks were discernible in plate. Shot broke up to much the same extent as that on Cammell's plate. The iron frame gave way badly at the angle nearest to the shot mark; depth of indent about $8\frac{1}{4}$ inches.

On the following day a second shot was fired at the Schneider plate with an increased charge of 479 lbs. of powder, which gave to the same nature of projectile as that used in the former rounds a striking velocity of 1,545 f.s., and a striking energy of 33,100 foot tons. This shot struck on a spot about 4 feet from the former shot mark, and split the plate quite across through the shot mark besides producing other fine cracks in radial directions across the plate, and bringing to view two or three hair cracks proceeding from the former shot mark. The head of the shot remained sticking in the plate, so that the indent could not be examined, but it was thought to be not much more that 8 inches deep. The injury done to the iron frame in the former round was now much extended.

The succeeding rounds were fired on November 20th, and included a second shot at each of the English compound plates, and a third and fourth shot at the Schneider steel plate, all with the heavier charge of 479 lbs. of powder, producing striking energies of about 34,000 foot tons.

The effects may be stated generally as follows: In the case of the English plates the second shot striking some 4 feet from the former shot marks did not penetrate very deeply, and no pieces of the projectile got into the timber backing; but in each case the plate was broken into five or six main pieces and detached from the target, leaving the backing entirely exposed, except where one fragment of Brown's plate was still held up by an armour bolt. All the armour bolts were broken short off except two. The shot of course broke up. The third shot fired at Schneider's steel plate was made of forged steel by the Terrenoire Company. It brought down about a fifth part of the plate, and some pieces of it were driven into the backing. The shot was not broken up but rebounded entire, though very much set up (length reduced from $44\frac{1}{2}$ inches to 28 inches), and flattened and deformed about the head. The fact of the plate not being removed entirely from the target by this round was due to the great number of armour bolts by which it was held. The iron frame was greatly damaged by this round and ceased to be of any service. The fourth shot fired at the steel plate was of Italian cast steel, and striking close to the top edge of the plate buried itself in the backing and rendered the whole target a complete wreck. The shot was found to be broken up.

The chief points to be noticed in this experiment are the following: The Schneider steel plate certainly stood the test of the first two rounds in a very remarkable way, for although it was cracked through it was not displaced by them, whereas the two compound plates had all but entirely disappeared from the targets after the second round. The number of bolts by which this steel plate was secured accounts no doubt partly for its not being so easily dispersed as the other plates were, but there still remains the fact that it was not cracked to any perceptible extent by the first round, and that after the second round it was not much more cracked than the other two plates were after their second blows. After the third blow it was as much broken up as the other plates were after their second round, but most of the fragments were kept from falling off by the armour bolts.

Weighing this result with other experiences of steel and compound plates, especially in an experiment to be mentioned later on in this paper, I am inclined to think that the steel plate made for these trials was of exceptionally good quality, and that the behaviour of the compound plates in comparison with it must not be taken as condemning their class of manufacture in general. They may not have been the best plates of their kind that can be made at Sheffield; and this would appear to have been the view of the matter taken by the Italian Government, judging from a speech made by the Minister of Marine, in the Chamber of Deputies, at Rome, on the 12th of April, 1883.

The armour bolts used in these targets gave way to a much greater extent than they should have done. This points to defects in the method of fastening them to the armour, and perhaps also to the quality of the steel of which they were made. Judging from experience gained at Shoeburyness under similar circumstances, it may be taken as almost certain that good wrought iron bolts, secured in the way described at page 178, vol. iv., would not have been broken unless they had been directly in the way of the shot itself.

The behaviour of the forged steel shell was not satisfactory, and from the nature of the trial but little information was gained as to the best kind of projectile for the attack of steel and steel-faced armour, a matter which is now becoming one of extreme importance.

To give some idea of the merits and disadvantages of steel and compound armour as compared with wrought iron plates, it may be mentioned that in the first three rounds of the above trial the projectile used would have pierced about 19 inches of ordinary rolled iron armour, and in the remaining rounds about 25 inches of the same material. Further, a target composed of two thicknesses of wrought iron plates, each 14 inches thick, would not only have offered complete protection against the gun used in this trial, but if it had been made of two such plates, and of the same length and breadth as the targets in the trial, it would have stood three rounds from the gun far better than either the Schneider steel or the Sheffield compound plates did, for the injuries would have been confined to the localities of the shot marks, and would not have involved the general destruction of the target. In fact, the target would have been quite fit to receive, if not another round from the 100-ton gun, at any rate several rounds more from lighter natures of ordnance. Again, a target composed of two 14-inch wrought iron plates, would cost considerably less than one of a single compound plate 18·89 inches thick, the other dimensions being the same, and very far less than a target of steel armour of the same size.

In this view, therefore, while for naval purposes, where the consideration of the saving of weight is one of paramount importance, the use of steel or steel-faced armour becomes almost a necessity, for fortifications on land, where increased weight has generally no disadvantage, there appears to be nothing in this experiment to warrant the adoption of either steel or compound armour, except, perhaps, in certain special cases, such as in that of revolving turrets and cupolas, where there may be advantage in keeping down the weight of the total moving load.

ITALIAN EXPERIMENTS IN 1883.

Before leaving this subject it may be mentioned that the Italian Government have in the autumn of 1883 fired at two other Sheffield compound plates which represented a quantity of armour which is being made in this country for the navy of that Government. The plates were 18·89 inches (48 c/m.) and 17·71 inches (45 c/m.) thick respectively, and about 8 feet square. Each plate was confined in a massive iron frame (of indifferent construction) and held by 16 armour bolts to a massive timber backing.

The gun used was the same as that employed in the last trial, and the charges were such as to give in the case of the thicker plate a striking velocity of about 1,550 feet per second to a chilled cast iron shot of 2,002 lbs. weight—equivalent energy 33,500 foot tons—and in the case of the other plate a velocity of about 1,460 feet per second to a similar shot—equivalent to 29,800 foot tons of energy.

These shot would respectively have pierced wrought iron armour 25 inches and $23\frac{1}{2}$ inches thick, but the indents made on the compound plates in the two rounds fired were estimated at only about 8 inches deep. Each plate, however, was cracked through in three or four places, and several other shallow cracks were formed on the face of each. On the whole I should say that the results were favourable to the use of compound armour for floating structures.

RUSSIAN EXPERIMENTS IN 1882–3.

The next trial to be mentioned is one which took place at Ochta, near St. Petersburg, on November 24, 1882, and March 8, 1883, in which a steel plate made by Schneider & Co. of the Creusôt works was compared with a compound plate ($\frac{1}{3}$ steel and $\frac{2}{3}$ wrought iron) made by Messrs. Cammell & Co. of Sheffield, on Wilson's system. It is not known for certain whether the steel plate was made by rolling or hammering, most likely it was hammered only. Neither is there information as to the proportion of carbon that it contained.

Each plate was 8 feet long by 7 feet wide by 12 inches thick, and weighed about $12\frac{1}{4}$ tons. Each was held in an iron frame and was backed by 12 inches of timber and two $\frac{3}{4}$-inch iron plates supported in rear by timber struts and braces. The steel plate was held to the backing by 12 bolts—the compound plate by 4 only.

The gun used for the trial was an 11-inch B.L. gun, throwing a chilled cast iron shell weighing 555 lbs. (Eng.) made at Perm in the Ural. Range, 350 feet.

The Schneider steel plate was struck by three shells, the first having a velocity of 1,500 f.s., the other two about 1,160 f.s. each. The energy at the former velocity would be about 8,865 foot tons, at the latter about 5,180 foot tons. Also at the former velocity the shot would pierce about 16 inches of wrought iron armour, at the latter about 12 inches. The first shot penetrated about 13 inches into the plate, and broke it into five pieces. The penetration of the second shot, which struck about 3 feet from the first, was about 16 inches, and the plate was now broken into nine pieces. The third shot passed completely through the target and went several hundred yards down the range, carrying away more than a quarter of the armour p'ate. The other pieces of the plate remained hanging on by the bolts in seven separate pieces. In this condition the plate was of course unfit to receive another shot. This shot was not broken.

The Cammell compound plate was struck by four shell, the first having a velocity of 1,500 f.s., the other three the reduced velocity of about 1,160 f.s. as before. The first shot indented the plate to a depth of about 6 inches only, and produced a few comparatively unimportant cracks on the steel face in both circumferential and radial directions. Three out of the four bolts holding the plate were broken in this round. The second shot struck about 2 feet 6 inches from the first, and caused an indent about $4\frac{1}{2}$ inches deep. A few more fine cracks were produced on the face of the plate, and a small piece of it was broken off. A piece of the steel face was also scaled off. The remaining armour bolt was broken, and the plate fell forward on its face. There were no cracks perceptible on the back of the plate. The plate was now provided with new armour bolts. The third shot struck about 3 feet from the second, and 4 feet 6 inches from the first. The line of fire was inclined about 12° from the normal. The point of the shot remained embedded in the plate. A few fine cracks were formed, and a small piece of the steel face near the second shot mark fell off. The plate was still quite fit for another round. The fourth shot struck in the remaining uninjured quarter of the plate and produced even less effect than any of the preceding shot. Only three fine cracks in the steel face were developed, and a piece of the steel face near the centre of the plate was shaken out. There was little or no damage perceptible on the back of the plate, and it was quite fit to receive another blow equal to those of the last three rounds.

Here, then, the palm must certainly be given to the English compound plate, which not only withstood individual shot with considerably less tendency to break up than was shown by the French steel plate, but which also stood blows equivalent in the aggregate to considerably more that 12,000 foot tons, and was fit to receive more, while the French plate was rendered *hors de combat* by blows amounting to a little more than 11,000 foot tons.

This is the result indicating a superiority in good compound over steel armour to which I referred above when drawing conclusions from the Spezia trials; and although it may be difficult to reconcile exactly the results of the two trials, the experience of the present one is so clear that it must not be disregarded. Possibly the best explanation of the anomaly is to be found in the fact that the treatment of steel in the course of its manufacture, at all times delicate and liable to variation, increases enormously in difficulty and uncertainty as the masses become greater.

The observations as to the faulty method of bolting the plates for the Spezia trials apply with equal force to the present case.

All the shot used at Ochta broke up on coming against the steel of the armour.

One of the consequences of the trial just described, and of the Spezia trials before mentioned, will in all probability be the use of more bolts for holding on compound armour than were formerly considered necessary. It has been proved by repeated experiments at Shoeburyness that one well-constructed and properly-fitted bolt to 10 or 12 superficial feet of plate is sufficient in the case of wrought iron armour, and on the first introduction of compound plates for ships' protection a similar proportion of bolts was generally adopted. In a severe trial of compound armour at Shoeburyness, in 1879, one bolt to 8 superficial feet of plate was found amply sufficient, but these bolts were of the improved pattern already mentioned. It is now thought by the manufacturers of armour, and by many others, that, in order to make up to some extent for the liability of compound armour to break up into detached pieces, it should be bolted on at closer intervals than is necessary for wrought iron armour, and it will be observed that, whereas in the Spezia trials of 1882 the Sheffield compound plates were held on by only one bolt to 15½ superficial feet, and in the Ochta trial of about the same date by one bolt to 14 feet, in the latest Spezia trial the English manufacturers bolted on their compound plate by one bolt to every 4 superficial feet. The Schneider steel plates tried at Spezia and Ochta were held by bolts in the proportion of one to 3·6 and one to 4·6 superficial feet respectively.

Whether this precaution of increasing the number of bolts for the hard and brittle kinds of armour will really prove efficacious in practice, seems somewhat doubtful at present; for at the best the protection afforded by a number of loose pieces of plate, hanging on by single bolts, could not be of much value, though there would, perhaps, be some little gain in the appearance of the structure after sustaining an attack.

It may be as well to mention here that the practice of enclosing steel and compound plates in massive frames for trial, has arisen with the view of giving to the plate support on its edges similar to that which it would receive from the plates adjacent to it in a continuous structure. A measure of this kind is not necessary with wrought iron armour, as that has but little tendency to give way by fracture and lateral separation.

Trial of 18-inch Compound Plates, at Shoeburyness, 1882-3.

In the course of some trials lately conducted at Shoeburyness, with the object of ascertaining the best kind of projectile for the attack of steel-faced plates, some further experience has been gained as to the resistance of this kind of armour.

In this series, extending from October, 1882, to the present time, 18-inch compound plates (6 inches steel, 12 inches wrought iron), manufactured by Messrs. Brown and Co., of Sheffield, have been used, and the gun, excepting for one round from the 16-inch M.L. 80-ton gun, has been the 12-inch B.L. gun of 43 tons. The shot from the latter gun would have pierced about 22 inches of wrought iron armour in one thickness.

Out of this practice three rounds only can be taken as giving clear results.

In each case the plate measured 5 feet by 5 feet, and received one round in its centre. It was confined, on all four sides, in a very strong frame, composed of rolled iron armour $16\frac{1}{2}$ inches by 5 inches in section, and was backed by a mass of oak 3 feet in thickness, supported in rear either by strong frames of timber piles and strutting, or by a butt of timber 6 feet thick placed in front of a massive iron structure.

The following are the particulars of the rounds in question.

No. 2,363. The projectile used in this round was a 12-inch compound shot, with a head composed of hard chilled cast iron and a body of steel, which was made by Messrs. Cammell and Co., of Sheffield, by pouring the cast iron of the head into a chill, and running upon this, while still hot, the steel to form the body. The shot was afterwards finished by turning and grinding. It weighed $708\frac{1}{2}$ lbs., and struck the plate with a velocity of 1,871 f.s., representing an energy of 17,200 foot tons. The plate stopped the shot, but they were both almost completely destroyed. The steel face of the plate was flaked off over a considerable area round the shot mark, and 12 cracks were formed, of which 6 extended through the plate. The actual indent, on which the point of the shot remained embedded, was 6·85 inches deep; but the point had not got quite through the steel of the plate. The bulge on the back of the plate behind the shot mark was 2·75 inches high. The shot was broken into a great many pieces.

No. 2,371. The projectile used was a forged steel shot, made by Messrs. Cammell and Co. by melting the steel in a crucible, and forging the ingot so formed, under a steam hammer, into rough shape, which was afterwards finished by turning and boring. The point was made separately and screwed into the head. The body and point were tempered in oil. It weighed 702 lbs., and struck the plate with a velocity of 1,862 f.s., and an energy of 16,850 foot tons. The shot penetrated to a depth of 8 inches, leaving its head in the indent, and broke up into about five large, and a great many small pieces. When the head of the shot was afterwards removed from the plate it was found to be separated into two pieces of very remarkable form, apparently caused by the sliding of the steel of the head whilst the harder material of the point had been still holding together with less change of form. There was also a peculiar separation of the steel of the plate in the shot-hole, forming a detached, cup-shaped piece of that material, bearing in its hollow an exact impression of the point of the shot. All the steel of the plate in the shot-mark, and of the shot's head, was intensely blue, and still very hot when examined. Altogether, there were unusually clear indications of the shot having expended a great deal of its energy upon itself, and, therefore, of its material having been of a quality quite unsuitable for the performance of the work for which it was required. The plate was broken into five main pieces by radial cracks, and there were other cracks of less importance in the steel. The bulge on the back of the plate was 2 inches high.

No. 2,381. A cored shot of chilled cast iron, similar in quality to the service Palliser projectiles, was used for this round. It weighed 716 lbs.; but, for some reason or other, it struck with a velocity of only 1,807 f.s., giving 16,200 foot tons of energy, or 1,000 foot tons less than that in 2,363, and 650 foot tons less than that in 2,371. It indented the plate to a depth of 6·9 inches, but, notwithstanding this, the point did not quite get through the face of the armour. The body of the shot broke into a number of fair-sized pieces, but its head and shoulder, with the exception of the very point (about 4 inches long), were reduced almost to powder. The plate was broken into six main pieces by cracks in radial directions, and there were other cracks on the face, two of which extended through to the back. The greater part of the steel face became detached from the rest of the plate through indifferent welding, and the parts immediately around the shot-mark were scaled off. The bulge on the back of the plate was 3 inches high.

The following may be said to be the results of this trial so far as it has gone. First, that forged steel shot, which have shown such marked superiority over every other kind of projectile in the attack of wrought iron armour at all velocities, and which promised so well in shot up to the 9-inch calibre (weight 275 lbs.), against compound armour at moderate velocities, have failed to maintain that superiority in the case of heavier shot (12-inch calibre, and upwards of 700 lbs. weight), employed at higher velocities against very thick masses of compound armour. Next, that the cast steel shot with chilled iron head has shown itself to be scarcely, if at all, better than the service chilled cast iron projectile for the attack of compound armour. (For the earlier trials of steel and cast iron projectiles against compound armour see Paper XII., vol. iv., of this series). The present trial further shows that little or no advance has been made of late in the manufacture of projectiles for the attack of hard armour. It has been found hitherto to be impossible to produce masses of steel of sufficient hardness to act upon steel and steel-faced armour without change of form and at the same time to stand the effect of the shock on impact without breaking up. In fact, that which was done with projectiles of Whitworth steel against wrought iron armour, when the same 9-inch shell was fired three times through 10 or 12 inches of wrought iron, has not been approached in the case of steel-faced armour. All kinds of projectiles hitherto used have been broken into pieces, or have become extremely deformed in being brought to rest, from even moderately high velocities, against steel armour; and this appears to be the case, so far as present experience shows, whether the impact be perpendicular or oblique to the surface. While, therefore, a chilled cast iron shot may, as in the above trial, break up into smaller pieces than a steel projectile against compound armour, yet, as it appears to operate almost, if not quite, as destructively as the other upon hard armour, there can be no advantage in superseding the cheaper projectile, which it is, moreover, easy to make of uniform quality, by one of costly and extremely difficult and uncertain manufacture. At any rate, until something very superior to the present steel shell has been produced chilled cast iron must be used against steel-faced armour. Further, as in the existing state of things it is quite hopeless to expect that any kind of shell will be found to carry a bursting charge through a considerable thickness of steel or steel-faced armour, it appears desirable that, for the attack of that kind of armour, shell should be made with the least possible internal capacity consistent with facility of manufacture, the projectile thus becoming more compact in form and stronger in the section of the body. In other words, it appears likely that we shall have to abandon shell and return, for the purposes of battering hard armour, to shot as nearly as possible solid. It is right to state that these trials of projectiles against steel-faced armour are still in progress, and that further experience in oblique fire will shortly be gained.

Attempted Improvements in Battering Projectiles.

It may be well here to mention that in the course of the last year or two various attempts have been made to improve upon chilled cast iron projectiles for battering purposes by encasing their bodies in strong steel jackets, with the hope that by this means their breaking up on impact would be prevented, or at least delayed; but after several trials with 9-inch and $12\frac{1}{2}$-inch M.L. guns against wrought iron and compound armour, little or no advantage has been found to attend this plan, while it involved considerable extra cost and much complication of manufacture. The trials in this direction have, therefore, been discontinued.

Another contrivance, which originated with the late Sir William Palliser, has been lately brought forward by his brother, with the view of getting increased effect with steel and cast iron projectiles upon compound armour. This consisted in making the head of the shot very long and tapering, with several raised ribs, of triangular section, running longitudinally along it from the point to the shoulder. The body of the shot was further incased in a steel jacket of peculiar form, the jacket being of the size to fit the bore of the gun, while the shot itself was throughout of a less calibre. The object of this design was, first, that the ribs on the nose of the shot should set up cracks in the steel of the armour, and next, that the steel jacket, after giving support to the body of the shot during the early part of its penetration into the armour, should be left behind, and the shot, thus diminished in cross section, should have to form a hole in the armour of considerably less diameter than the calibre of the gun. This principle had a fair trial at Shoeburyness in 1883, in practice from a 6·3-inch 80-pounder M.L.

converted gun, against 6-inch compound armour in comparison with Palliser cored shot of service pattern, and special shot with long heads unjacketed; also in practice from the 13-pounder gun in 1882, against 4-inch and 5-inch compound plates; but the experiments did not show any superiority in the proposed form of projectile over that of the service form for the attack of compound armour.

Trial of Armoured Masonry at Shoeburyness, 1883.

The last trial of compound armour that remains to be noticed is one which took place in the course of an extensive experiment carried on at Shoeburyness, in 1883, with the object of testing various methods of strengthening the masonry parts of existing sea forts. As this experiment, when concluded, will be reported in full elsewhere, I should not notice it here at all were it not that it has afforded two very distinct results, bearing closely upon the subject of this Paper, the discussion of which will not in any way forestall the general consideration of the results of the whole trial when the report appears. The two targets to be here noticed may be briefly described as follows:

One consisted of a 12-inch compound armour plate (4 inches of steel and 8 inches of wrought iron), measuring 7 feet by 7 feet on its face, made by Messrs. C. Cammell and Co., of Sheffield. It was confined in a frame composed of heavy bars of wrought iron ($16\frac{1}{2}$ inches by 5 inches in section), and bolted to a mass of masonry, with 5 inches of American elm intervening, by four wrought iron armour bolts, each 3 inches in diameter and 15 feet long, screwed a short way into the back of the plate. The steel of the plate contained 0·57 per cent. ot carbon. The masonry consisted of a granite face built of stones 5 feet and 3 feet 6 inches thick in alternate courses, backed by 10 feet of Roach Portland stone and 8 feet of cement concrete, and brickwork. The thickness of the masonry was thus 22 feet.

The other target consisted of a sandwich of two 8-inch wrought iron plates, made by Messrs. Cammell and Co., bolted together by six 3-inch armour bolts fitted with spherical nuts, with 5 inches of American elm between them. The entire sandwich was held to a masonry wall, precisely similar to that in the other target, by six 3-inch bolts 15 feet long, fitted with spherical nuts in the rear armour plate and hexagon nuts in the masonry. There was also a layer of 5 inches of elm between the armour and the granite.

The gun used was the 16-inch M.L. gun of 80 tons, at about 200 yards range.

The projectiles were the service Palliser shell weighted with sand up to 1,700 lbs., and fired with the service battering charge of

450 lbs. prismatic[1] powder. In the round at the compound plate the striking velocity was $1{,}577\frac{1}{2}$ f.s., and striking energy 29,354 foot tons; in that at the wrought iron target the velocity was 1,568 f.s., and the energy 29,000 foot tons. The effects were as follows:—

In Round 2,385, at the compound plate, the shell was brought to rest with its point 13 inches beyond the back of the plate, or 9·8 inches in the granite. The head and part of the body of the shell remained in the shot-hole (with its point inclined a little upwards), but broken, the pieces of the rest of the projectile falling on the ground in front of the target. The plate stood remarkably well. The steel around the shot mark was turned inwards and broken circumferentially over a circle of about 2 feet diameter, and there were 9 radial cracks on the face, those on the proper right of the shot mark extending to the edge of the plate, and being there about $7\frac{1}{8}$ inches deep, but the plate was not broken through at any part. On the rear of the plate a bulge some 5 or 6 inches high and 40 inches in diameter was formed up around the shot's head, but there were no cracks whatever on the back of the plate outside the area of this bulge. The plate was bent or buckled vertically on its proper right edge to the extent of nearly 1 inch. There were no bolts broken. The injury done to the masonry wall was confined to the crushing of the face of the granite block at the place where it was struck by the point of the shot and the cracking of the adjacent stones with a slight displacement of them. The brickwork at the back of the masonry wall was very slightly bulged and cracked. On the whole, the behaviour of this plate may be said to have been more satisfactory than that of any other compound plate yet tried. It was no doubt a plate of very superior manufacture, and the rigid support given by the mass of masonry behind it was much in its favour. There has been no previous instance of a compound plate remaining entire after its perforation by a shot bearing the proportion in the present round of diameter of shot to size of plate. The very local character of the injury done constitutes another main feature of this round.

In Round 2,384 against the wrought iron sandwich target the shell pierced the two 8-inch plates and penetrated 8 feet into the masonry behind them. The injury to the armour was confined to the immediate locality of the shot-holes. There were no cracks set up, and the fastenings were quite uninjured. The shot was found cracked and broken into fair-sized pieces at the end of the hole which it formed for itself in the masonry. The stones forming the front of the masonry wall were more or less cracked, and were a little displaced, the joints being opened slightly, and the stones of the course which received the shot were moved a few inches sideways. The brickwork which formed the back of the masonry wall was slightly shaken as in round 2,385 on the other target.

Had the wrought iron plates used in this target been made between $9\frac{1}{2}$ and $10\frac{1}{2}$ inches thick, instead of 8 inches, which would have made their cost together correspond with that of the 12-inch compound plate in the other target, it is calculated that the penetration into the masonry would have been much the same in both rounds, and then no doubt the effect on this target would have been even more local in character than on the steel-faced target.

Considerable importance attaches to this trial because it has certainly shown an effectual way of making existing masonry proof against any battering guns that can ever be produced, though the great expense of armour-plating large surfaces makes it very desirable that some less costly expedient should be found effective.

Chilled Cast Iron Armour.

It only remains now to notice briefly the state of the question in regard to the use of chilled cast iron armour. It has been explained on former occasions that the principal advocate for this kind of armour is Herr Grüson, of Magdeburg, who has large means of producing it at his works at Buckau near that town.

At page 270, vol. VII. of this series will be found a short account of the early trials of chilled cast iron here and on the Continent, but in this country, for want of further experiment, the problem to which I referred in that paper is no nearer to a solution than it was when there propounded. On the Continent, however, the matter has not been allowed to rest, and not only have further trials been made but cast iron defences have been actually proceeded with in many countries both for land and sea fronts.

According to the best accounts that can be obtained of these proceedings it would appear that on the Continent there are already, or very shortly will be, about 100 guns of various classes, varying up to 38 tons in weight, mounted behind chilled cast iron armour. Of these 55 are in 30 revolving turrets, and there is reason to believe that the Italian Government contemplate setting up cast iron turrets, each of which will mount two 100-ton guns of recent type. At Fort Langhützen alone, which commands the mouth of the Weser, there are nine 21-c/m. B.L. rifled guns mounted behind fixed Grüson shields, the maximum thickness of the metal of which is $28\frac{1}{2}$ inches, and six 28-c/m. guns in turrets of the same material upwards of

31 inches thick. In Austria, Belgium, and Holland there are batteries of the same class mounting guns almost as heavy as those at Langhützen, and as regards land fronts there are certainly cast iron shields already existing at Strassburg, Metz, and other fortresses. France, I believe, has not yet made any use of cast iron in her defences.

Even leaving out of consideration the question of whether cast iron defences might be advantageously used in this country—for my own part I think it extremely doubtful whether there would be any gain whatever in using this material—there is still a strong reason for making experiment with such works, because, without the experience that can be gained only by trial, it is impossible to say what would be the best way of attacking the cast iron batteries which will surely have to be dealt with in future wars.

Beside the early experiments on the Continent already referred to, namely, those at Tegel in 1869, and others in 1873 and 1874, and one at Meppen in 1879, further trials have recently taken place at Grüson's armour works.

One of these came off in the winter of 1882-3, when a turret plate, which had been rejected on account of some small fissures called "chill cracks," produced in the course of manufacture, was tested by firing a 5·9-inch Krupp B.L. gun at it. The plate weighed 13 tons 15 cwt., and measured 17·7 inches at its thickest part. Forged and tempered steel shell weighing about 78 lbs. were fired with charges of prismatic powder, giving a muzzle velocity of 1,476 f.s., and an energy on striking of about 1,200 foot tons. The range was 23 yards. It will be at once observed that these shells, with so low a velocity, gave a very inadequate test of so thick a plate. They would have perforated only about 8 inches of wrought iron, but to make up for this the fire was concentrated on small surfaces. Thus three rounds were placed within 60 square inches, and nine in an area of 24 inches by 15 inches and 13 rounds in all representing 16,000 foot tons of energy, were delivered with very small effect upon the plate. The chill cracks proved to be of little importance. However, as the delivery of a number of comparatively light blows on a mass of cast iron is plainly not the most effective way of attacking it, there is, I fear, not much to be learned from this trial. It was intended at the time that the experiment should be afterwards continued, but nothing more has been heard of it.

Another trial, which took place at Buckau, on October 22, 1883, was more instructive in its results than that just described. The target used on this occasion was composed of one of the plates made for a cast iron turret for two 30·5-c/m. guns for the Dutch

Government, which had been objected to on account of ten chill cracks which had appeared on its outer face after it was cast. This plate was set up between other turret-plates, two on either side of it, and the entire target was supported in rear by masonry piers. There was also a roof-plate laid on the top, so that the structure roughly repesented half a turret. The plate to be fired at weighed 47 tons, it had a maximum thickness of 43 inches, and a mean thickness in the parts struck of about 35 inches. It was curved both vertically and horizontally.

The gun selected for the trial was a Krupp 30·5-c/m. (12·008-inch) gun, throwing steel shell weighing 445 kilogrammes (981·05 lbs.), with a velocity on striking the target of about 1,460 f.s., giving an equivalent energy of about 14,500 foot tons. The gun was thus somewhat less powerful than our 12-inch B.L. gun of 43 tons, which, at the short range (30 yards) used in this trial, and the present charge of 260 lbs. prismatic powder, would have struck the target with a blow equivalent to about 15,600 foot tons. The corresponding penetration of wrought iron by the two guns at this range would be 20 inches and 21-inches respectively. After three rounds striking on the points of a triangle with sides 34 inches, 35 inches, and 40 inches in length, the angles at which the shell struck being 93°, 51°, and 75° respectively, the cast-iron was cracked through in four places, and was virtually separated into several large pieces. Even after the first of these rounds two cracks were observable on the back of the armour. The indents caused by these rounds averaged only two inches in depth, but the metal round the shot marks scaled off a good deal, and there were a good many cracks of minor importance on the face. The fourth shell struck on a point 50 inches from the centre of the triangle marked by the other three shells, and 33 inches from the point struck by the nearest of them. It fairly breached the plate, and broke it into six separate pieces, doing such damage as would inevitably have placed a fighting turret completely *hors de combat.*

To help in forming an opinion as to whether this result may be fairly considered favourable or otherwise to cast iron defence, it may be stated with confidence that for the cost of this cast iron plate a shield affording equal cover could be made of good wrought iron armour, which would stand four rounds similar to those fired at Buckau without being breached, and it is equally certain that if such a wrought iron plate were to be subjected to further trial until ultimately pierced the resulting injury would be of a much less serious character than that which was done to the cast iron target. Moreover, had the aggregate energy of two or three of the blows delivered at Buckau been expended in a single blow from a much heavier gun, there can be little doubt that the cast iron would have been broken through and that the turret would have ceased to exist as a defensive work; whereas, the effect of an overpowering blow delivered on wrought iron armour being more local in its effect, a turret made of that material might be pierced by such a blow as that assumed above without being totally destroyed. No doubt there is great advantage on the side of the cast iron in the roundness of the form which may be given to it, which makes it very difficult to hit it at any but very oblique angles of incidence; but, on the other hand, there is the great disadvantage that a cast iron structure cannot be afterwards strengthened by applying additional thicknesses as can be done with ease in the case of other kinds of armour. The enormous increase of weight involved in the use of cast iron for turrets and other moving structures, as compared with wrought iron or steel, constitutes another objection which cannot be overlooked.

With this I must bring the subject to a close, for the present at any rate.

January 10th, 1884. T. I.

PAPER XII.

MODERN TYPES OF GUNS.

Being the Substance of Two Lectures delivered at the Royal Engineers' Institute, Chatham, in the Spring of 1884.

BY LIEUT.-COLONEL F. G. BAYLAY, R.A.

MODERN GUNS.

Before entering upon a description of the newest form of guns, it will, perhaps, be as well to take a short retrospect at the class of guns they are gradually replacing, in order to see what the shortcomings of the older pieces are, and to enable us more clearly to understand the object of the various changes, in form and construction, introduced in the new Steel B.L. guns.

You are all doubtless intimate with our heavy M.L. Ordnance, commonly called the Woolwich guns, which constitute the armament of our coast defences, and with which the Royal Navy are still almost exclusively armed. I refer to the following pieces, viz.:—The 80 and 38 ton guns; the 12″ gun of 35 tons, formerly termed 'The Woolwich Infant'; the 12″, 11″, 10″, 9″, 8″, and 7″ R.M.L. guns.

Before you (see Pl. 1.) is a diagram of the Mark II. 38 ton gun, which I have selected as being one of the most recently-constructed and best-known pieces of this group, and one which embodies most, if not all, of the latest improvements applied to this class of ordnance.

The guns of this type consist of an inner tube of tough steel,

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tempered in oil, strengthened by wrought-iron coils shrunk on, and having the end of the inner tube supported by the screwed-in cascable.

It will be observed that these Mark II. guns are slightly chambered, which was a modification introduced with the view of air-spacing the cartridge, aud so guarding against excessive chamber pressure when the charge was raised to 210 lbs.; the bore is nearly 16 calibres in length.

The weak points of this M.L. system, which it has been successfully sought to overcome in the Steel B.L. Guns, may be briefly summed up as follows:—

1. Their great weight, in proportion to the results obtained in respect of 'energy,' owing to their being built up of a combination of steel and wrought-iron, instead of being made solely of the stronger metal, steel. That this form of construction was so long adhered to may perhaps be in some measure attributed to the difficulty experienced, at even a comparatively recent date, in obtaining trustworthy qualities of steel, and hence the marked dislike that was exhibited in this country to rely solely on steel for gun manufacture.

2. Owing to the limits imposed on their length (from the fact that they were required to recoil inboard to enable them to be loaded),* they could not be made of a length sufficient to enable them to profitably consume a large charge of slow-burning powder; but indeed we did not, at the time these guns were made, possess the valuable slow-burning powders that have lately been introduced.

3. The fact that they could not be chambered except to a very limited extent; because, if largely chambered, they could neither be properly sponged out, nor could the cartridge be got to expand into the chamber.

That this was no inconsiderable drawback will be seen when reference is made to the B.L. Guns.

4. The great length of recoil requisite to enable the gun to be loaded was often a source of inconvenience, especially in works originally designed for smaller pieces.

5. Very long sponges and rammers had to be manipulated, besides which all the work of loading had to be performed in the often exposed position about the muzzle.

There is no doubt that although the guns of this type have done

* In a few exceptional cases, like that of the 'Thunderer,' the guns were loaded by means of hydraulic machinery, from loading chambers outside the turret.

good service (and may do so again), they would be heavily handicapped if called upon to contend, on even terms,* with modern B.L. guns, such as those which have for some time past been turned out in large numbers by foreign Powers; hence a new departure in our own gun manufacture became urgently necessary, and the breechloading system again came to the front in this country.

Steel B.L. Guns.

As these guns are built up entirely of steel, it will be well, in the first place, to explain what advantages obtain from the exclusive use of that metal, and wherein it is superior to a combination of wrought-iron and steel for purposes of gun construction. Modern breech-loaders.

With respect to the iron and steel used in gun manufacture, it may be stated generally that the iron only possesses about one-half the elasticity and one-half the tensile strength of the steel employed. Hence, if it were attempted to turn out guns of iron and steel combined, *of equal power* to the new steel guns, the result would be enormously heavy and unwieldy pieces, and moreover their carriage and platforms would of necessity, to a considerable extent, labour under the same disadvantages.

The general principles that guide the construction of the new guns may be stated to be as follows (see Pl. II.):— General principles of construction.

1. To so build up the gun and regulate the shrinkage that each part may at the moment of firing take its fair share of the strains set up. (This principle applies to all built-up guns.)

2. To make the bore of such a length as to enable a large charge of slow-burning powder to be profitably consumed (charges as high as half the weight of the projectile are used in several of the new guns).

3. To make use of a chamber of such diameter that the cartridge containing the desired charge may not exceed a length of about four diameters. If longer cartridges are used, not only is there a tendency for wave-action of a destructive nature to be set up, but the working length of the bore is diminished.

4. To relieve the inner tube of longitudinal strain by screwing the breech-screw into the breech-piece instead of into the inner tube.

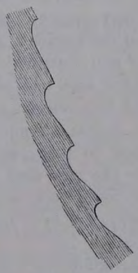
* The expression 'even terms' may be taken to refer either to a case in which guns are opposed by others *of the same calibre*, or to one in which guns *of equal weights* are opposed; in either case the advantage would rest largely with the breechloaders.

5. To guard against possible separation of the component parts of the gun by the use of the 'key-ring' (shown on Pl. II.), and by employing shoulders to give the necessary bearings.

6. To distribute the work of imparting rotation over the whole surface of the bore by employing a polygroove system of rifling.

7. To make use of grooves of such form in section as will only present shallow curves for the gas to act upon. The loading edge (which is no longer necessary) disappears in the hook form of rifling now used.*

Hook form of rifling.



8. To make use of such a spiral for the rifling as will sufficiently rotate projectiles of the length intended to be used, and will at the same time throw the least possible strain on the gun and on the projectiles. Speaking generally, the spiral employed is one increasing from about 1 in 120 to 1 in 30 in the smaller, and to 1 in 35 calibres in the larger natures, at half way up the bore, from which point it is uniform.

9. To employ such a system for closing the breech as will secure the following desiderata, viz.:—

Safety.
Perfect obturation (or gas-tight joint).
Ease in working.
Simplicity in construction.
Durability.

* The more nearly the form of groove approaches the form of an *angle*, the greater the tendency of the tube to split; even a straight deep scratch or scoring has been found liable to initiate a splitting action.

These qualities are all existent in the present system, which consists of a breech block fitted with an interrupted screw and a De Bange obturator.

Taking the 8-inch B.L. gun of 13 tons as an example (see Pl. II.), we see that it consists of an inner, or A, tube, strengthened externally by the breech-piece and B ring, which are keyed together by the key-ring, S, which consists of two separate half-rings, held in their place by the C ring, in rear of which are placed the trunnion-ring and four hoops (1D, 2D, 3D, and 4D). It will be observed that the breech block is screwed into the breech-piece, whereby the A tube is relieved of the longitudinal strain, and that this tube is made thinner, and hence of less strength in proportion to the surrounding mass than was formerly the case, so that, in the event of its failing, there would still be sufficient strength in the gun to guard against an explosive burst.

The steel used in gun construction is of a 'low' or 'mild' nature, containing only a small percentage of carbon (from 0·2 to 0·3 p. c.). The whole of the different parts of which the gun is built up are, with the sole exception of the trunnion-ring, tempered in oil.

The construction of the gun is so intimately connected with the powder it is intended to burn that it will be well to offer a few remarks regarding the natures of powder now being used for our heavy guns.

Powder.

One of the greatest, and as yet only partially solved, difficulties connected with the monster guns of the present day is the provision of a suitable powder. To quote the words of Colonel Maitland:—'If a powder is of too violent or rapidly-burning a character, a vibratory or "wave" action will be induced in the chamber, and this it is particularly desired to avoid, as it is injurious to material and useless towards the production of velocity. The ideal powder would be one which should burn slowly and regularly, giving off its gas so as to yield gradually increasing pressures equal in all parts of the powder chamber at the same time.'

Sir William Armstrong quotes an instance of an experiment in which the normal pressure of 18 tons was raised to over 50 tons per square inch, and adds: 'The extra pressure is all "wave-action," and chiefly takes effect longitudinally, thereby tending to tear the gun asunder.'

In order to guard against this destructive action, powder, very large in grain and of high density, is now employed for the charges of the heavier natures of guns, and the chamber is kept within moderate limits of length: a quick-burning powder and long chamber, especially if combined with a system of igniting the cartridge in rear (which, for sufficient reasons, is the plan now adopted for heavy guns), having been found to be the means most likely to induce wave-action.

The following table shows the natures of powder now used with the newer type of guns.—

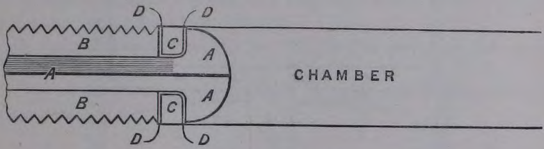
TABLE A.

Designation of Powder.	Shape of Grain.	Size of Grain.	Weight of each grain, approximate.	Finished density.	Moisture P.C.
P . .	Rough cube	½-in. side .	80 pieces to the pound.	Not less than 1·76	1 to 1·3
P^2 . .	Do. .	1½-in. side .	5 pieces to the pound.	Not less than 1·75	1 to 1·3
$Prism^2$. .	Prism .	Diameter over sides, 2·35″. Height of prism. 2·00″. Diameter of hole, ·575″.	1·7 pieces to the pound.	Not less than 1·76	1 to 1·3
Pris m .	Do. .	Diameter over sides, 1·38″. Height of prism ·98″. Diameter of hole, ·375″.	10½ pieces to the pound.	Not less than 1·75	1 to 1·3
C^2 . .	Cylindrical	Diameter of cylinder, 1·75″. Height of cylinder, 2·00″. Diameter of hole ·25″.	3·16 pieces to the pound.	Not less than 1·83	1 to 1·3

In the case of a cartridge made up with C^2 powder (which is one of the latest developments in powder manufacture), it will be observed that not only is free passage for the flame afforded throughout the mass, through the holes in the cylinders, and the interstices existing between them (a most important point), but a certain and constant amount of air-space is secured by the existence of these holes and interstices, whereby the density of the charge is reduced, and excessive pressure guarded against. So much is this the case that we are now securing velocities as high as 2,000 f.s., with maximum pressures of only about 17 or 18 tons per square inch, and the volume of slowly-evolved gas is sufficiently great to exert a pressure as high as 5 or 6 tons per square inch, even at the muzzle end of a bore 30 calibres in length.*

It is only by the maintenance of strong, but never excessive, pressures throughout the whole length of a long bore that a high velocity can be imparted to an elongated projectile, without the exertion of destructive force.

The 'De Bange' Obturator.



De Bange obturator.

This method of obtaining a gas-tight joint at the breech consists of a moveable mushroom-headed spindle made of steel, A A A, having a ring, C C (made of asbestos fibre, soaked in grease, and contained in a canvas envelope), between it and the face of the breech block, B B. Discs of soft metal, D D, are placed in front and in rear of the asbestos ring.

On the ignition of the charge, the pressure of the gas on the mushroom-head causes it to set back on to the ring of asbestos fibre, which is thereby compressed and forced out laterally into hard pressure against the surface of the chamber, forming an absolutely gas-tight joint.

The chamber is coned out in rear of where the ring, C, takes its bearing, to facilitate the withdrawal of the breech block, B, after firing.

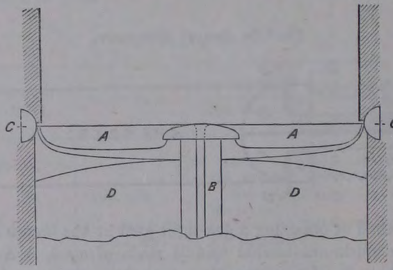
The asbestos ring will stand a large number of rounds before the canvas envelope wears out; and it can be changed with ease and rapidity if required. An axial vent runs through the centre of the spindle, A A.

One great advantage possessed by the expanding ring is that it accommodates itself to any change of surface produced by grit, wear, &c.

* When the charge is comparatively small, in proportion to the calibre, the pressure naturally falls off very fast; thus, in the case of a 38-ton gun, the calibre of which is 12·5 inches, a charge of 130 lbs., P.², only yielded a pressure of about 1 ton per square inch at the muzzle end of a bore only 16 calibres in length.

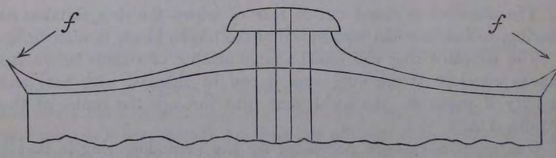
This system—which has, so far, given excellent results—superseded the steel cup obturator, with which, however, a few guns are still fitted.

Steel Cup Obturator.



This mode of obturation consists of a steel cup, A A, held by the spindle, B (through which the vent passes), against the front face of the breech block, D D, which is slightly convex.

On the ignition of the charge, the pressure of the gas causes the unsupported portion of the cup to set back, as shown in the subjoined diagram, thereby increasing the tendency of the edge of the cup to



form a gas-tight joint with the copper ring, C C, which is secured in the gun at the rear end of the chamber. The pressure of gas acting in the direction *f*, *f*, has also the same tendency.

The convexity of the front face of the breech block is exaggerated in the diagrams to aid explanation—in reality it is very slight.

The following were the weak points in this system :—

1. Occasional fracture of the steel cup in the heavier guns.

2. If any particle of matter, such as a grain of sand, got between the copper ring and the edge of the cup, there was no longer a perfectly gas-tight joint at that point, and the gas escaping at high pressure eat away a minute portion of metal, both from the edge of the cup and from the copper ring.

It is true that the cup could be turned round on the spindle, but this only partially remedied the evil; the only true remedy being to re-face the copper ring, and use a larger cup.

In time, of course, the evil recurred, and a new ring had to be fitted, and so on.

This system was more successful in small and medium than in heavy guns.

Trepanning.

It hardly falls within the scope of the present lecture to enter into any manufacturing questions, but I think an exception may perhaps with advantage be made in the case of the new mode of hollowing out steel tubes and breech-pieces.

These are formed of cast steel ingots, drawn out under the hammer to nearly the required size externally, after which the core is 'trepanned' out; *i.e.*, instead of being turned out in fine shavings as formerly, the core is removed in an unbroken cylinder, which is worked up for the smaller natures of guns. By this means a great saving of expense and material is effected, some of the cores so removed being worth hundreds of pounds as a mere cylinder of steel.

The operation may be briefly described as follows :—

The steel cylinder from which the solid core has to be extracted is caused to revolve in horizontal bearings by steam machinery; against one end of it is pressed the trepanning instrument, which may be described as a hollow cylinder of steel, about an inch in thickness, carrying a number of steel cutters on its end. It is grooved both on the inside and externally, the inner groove serving to convey a constant stream of soap and water to the points where the cutters bear, and the outer grooves acting as outlets for the water, which carries with it the steel shavings cut from the cylinder as the instrument eats its way in. When half the solid cylinder has thus been trepanned out, it is turned end for end, and the other half treated in like manner, by which means a solid core is separated from its centre.

Projectiles.

The means of imparting rotation in the new system consists of a soft annealed copper ring squeezed on into an undercut groove near the base of the shell by hydraulic pressure. The diameter of this ring being rather greater than that of the bore of the gun, it follows that the copper is forced into and fills the grooves of the rifling on the gun being fired.

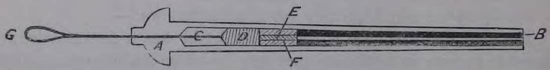
The proportion that the weight of the projectile bears to the calibre of the gun is expressed by $\frac{W}{d^3} = \cdot 5$, where W is the weight in pounds of the projectile (to be determined), d the calibre. For example, in the 10-inch B.L. gun $\frac{W}{10^3} = \cdot 5 \therefore W = \cdot 5 \times 1000 = 500$ lb., the weight of the projectile; with medium guns ·4 comes nearer the mark.

Vent Sealing.

With very long guns, using large charges of slow-burning powder, the rush of gas through the vent would have the effect of rapidly eating it away; besides which, if axial-vented guns were fired with ordinary friction tubes, the tubes would be blown back in a way that might prove dangerous. To avoid these evils heavy and medium guns are now fired either with vent-sealing tubes or percussion primers, which are prevented from flying out by a sliding mask.

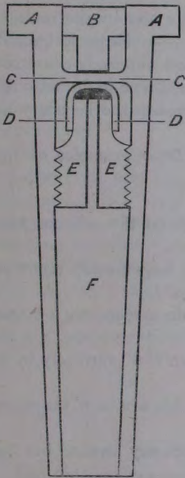
These tubes and primers may be described as follows:—

Vent-sealing Tubes.



The tube consists of a steel envelope, A, having a coned recess, C, in its head. The coned cylinder, D, before firing, occupies the position shown in the diagram with its file-like tongue, E, embedded in the detonating composition, F. On firing, the wire, G, draws the coned cylinder, D, back into the coned seat in the head of the tube, ignites the detonating composition, F, and the hollow column of compressed powder, B. The pressure of gas acting inside the now empty tube expands it laterally and makes a gas-tight joint, while the coned piece, D, prevents any escape through the tube.

Percussion Primers.



For Naval guns, where instantaneous firing is essential, a percussion primer, fired with a spring-hammer and trigger is used. It consists of the metal envelope, A, carrying in its recessed head the firing-pin, B, which is supported by the bridge of metal, C; immediately in contact with the bridge on the other side of it is the cap, D, on the anvil, E.

The body of the primer, F, is filled with F.G. powder.

On the trigger being pulled, the spring-hammer falls on B and fires the cap. The gas is prevented passing through the primer when the gun is fired by the bridge, C.

Relative Power of the New Type Guns compared with those they are designed to replace.

A reference to the tables of M.L. and B.L. guns will enable an opinion to be formed in this respect. Relative power of M.L. and B.L. guns.

Taking two examples from the heavy guns of each type we have:— Comparison of muzzle energies.

M.L.	12·5″,	38 tons,	M.E. of shell,	13·554	foot tons.
,,	10″	18 ,,	,,	5·288	,,
B.L.	12″	46 ,,	,,	23·569	,,
,,	10″	26 ,,	,,	15·285	,,

The superior accuracy of the new B.L. guns as compared with the M.L. may, I think, be attributed to the following causes, viz. :— Superior accuracy of the B.L. guns.

1. The more perfect centering of the projectile in the new system, and hence greater steadiness in flight.

2. Higher velocity, hence shorter time of flight and less influence exerted by wind.

3. The fact of the projectile being held in its seat by the rotating ring for an appreciable interval of time after the charge is ignited, enables the powder to be more thoroughly and uniformly consumed than was the case in the older system; this would tend to decrease the vertical dispersion, or, in other words, to increase the accuracy as regards *range*.

It may be interesting to quote two or three examples of the accuracy of the new pieces.

At 1,000 yards range at Shoeburyness :—

The 9·2″ B.L. gun put ten shots in succession through one hole 15″ × 18″ in size.

(The 9″ M.L. is not certain to hit a 6′ × 6′ target every round at this range.)

The 12-pr. B.L. put nine successive shots into a space on a target 2′ 6″ × 2′ 3″.

The 6″ B.L., a short time ago, made a pattern 2′ 6″ vertically by 2 horizontally.

(The 64-pr. M.L. would not with certainty hit a 9′ × 9′ target at this range.

These great advances in power and accuracy cannot but be considered very satisfactory.)

Concluding Remarks.

When we consider the great responsibility that attaches to the working out an entirely new system of gun construction, the many important questions and vast mass of details that have to be solved by the light of science and thorough practical knowledge, and the numerous changes in manufacturing plant and appliances that must of necessity be provided for, I think you will agree with me that the great strides that have of late been made in gun manufacture, and the happy results that have attended them, reflect the highest credit on the Royal Gun Factories, and on the very able and energetic officer who we fortunately have at the head of that department.

In conclusion, it will be interesting to consider what bearing this great increase in the power of modern ordnance has, at the present moment, on the position of this country with reference to other Powers. We know that for some time past first-rate Continental Powers have been straining every nerve to bring their naval armaments up to modern requirements, and that in France especially they have the means of turning out annually a large number of guns of the most formidable nature. In this country we can hardly claim to be in so forward a stage as regards re-arming; and what is chiefly to be dreaded is that the immense sums of money that must necessarily be voted to enable a complete change of armament to be carried out will not be speedily forthcoming.

We have always prided ourselves on our naval supremacy, and it is (comparing us with other Powers) our only strong point, failing which we should be in a sorry plight indeed. Well, I only ask you to consider what would be the probable result of an action between two first-class iron-clads, one armed with the old and the other with the new style of ordnance; and unless the conclusions you arrive at coincide with my own, I shall feel that I have, in great measure, failed to bring home to your minds the fact of the great superiority of the guns of the new type over those they are designed to replace.

Miscellaneous.

Guns of Riband (Wire) Construction.

For the late experiments at Lydd two pieces of "Riband" construction were furnished by the Elswick firm, viz., the 6″ B.L. gun of 60 cwt., and the 6·3″ jointed R.M.L. howitzer of 17 cwt. (made for elephant transport in India).

Riband form of construction.

The advantages claimed for this system are great circumferential strength in proportion to weight of metal employed, and hence the production of powerful results out of comparatively light pieces, like the 6″ wire gun above referred to.

This method of construction, which may be said to be yet in its infancy, consists of the winding on at high tension of successive layers of highly-tempered steel wire (rectangular in section) over the steel tube or breech-piece of the gun.

Sectional area of wire about ·25 × ·05.

The tension employed in winding on the wire reaches as high, I believe, as 60 tons per square inch.

The fact that the metal is able to withstand such a strain is to be accounted for by the great density and strength: which result, in the first place, from the process of 'wire drawing;' and in the second, from the wire being highly tempered. I have been given to understand that steel wire so treated has exhibited a tensile strength considerably over 100 tons per square inch; its great strength enables it to be wound on at the tension indicated, and the compression thus exerted on the tube of the gun is such as to induce an appreciable diminution in the diameter of the bore (before 'fine-boring').

6″ B.L. Armstrong Wire Gun of 60 Cwt.

This gun was constructed to throw an 80 lb. shell with a battering charge of 34 lbs. of P^2 powder (if used against iron-plated structures), the ordinary charge being 25 lbs. P^2.

It was mounted on a hydro-pneumatic carriage, which pivoted on an 'A piece,' anchored in and under the parapet (see Pl. III).

The A piece, which weighs 39 cwt., is capable of being taken to pieces for transport.

The carriage, with transporting wheels and axle complete, weighs (without the gun) 72½ cwt., but it is likely that future patterns will be made much lighter.

In order to anchor the 'A piece' two service howitzer anchorages were successfully employed, and the 'A piece' was further prevented from lifting in front by a beam 10′ × 9″ × 9″ placed across its front end, over the beam 8 oak planks 4′ × 12″ × 3″, and over all the earth of the parapet. Thus it will be seen that to get the gun into position ready for action a large amount of material has to be moved, the weights of which, without the anchoring arrangements, are:—

Gun	60 cwt.
Carriage complete	72½ "
Limber	12 "
A piece	39 "
Total	183½ cwt.

or rather more than 9 tons. It may be observed that it is unlikely that any powerful piece could be brought up and securely anchored without moving a very considerable weight of material.

This gun made very good practice, and the carriage worked admirably. The general principles of the H.P. carriage of this piece are the same as those of the H.P. carriage of the 6-6″ R.M.L. gun, which will be described hereafter; the air pressures were 1,200 lbs. per square inch gun down, and 700 gun up.

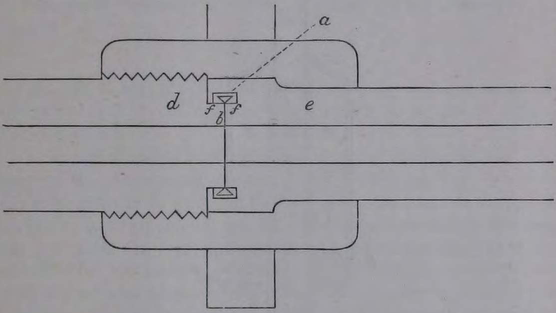
6·3-inch R.M.L. Jointed Howitzer.

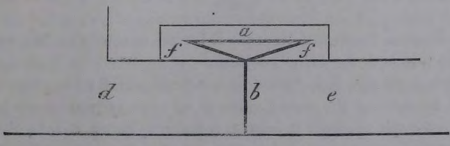
In the experiments before referred to, a jointed 6·3-inch R.M.L. howitzer, supplied by the Elswick firm, was also tried.

This howitzer, which was of the riband or wire form of construction, was in three parts, weighing respectively about 7, 7, and 3 cwt.

The photographs show its form both in separate parts and put together.

There is not much to remark about it except the clever method of securing a gas-tight joint where the breech and muzzle tubes meet.





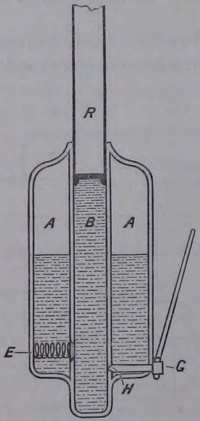
The steel ring '*a*' is inserted over the joint '*b*,' where the breech tube '*d*' and the muzzle tube '*e*' meet. The gas acting on the flanged surfaces '*f*,*f*,' press them down, and so make a gas-tight joint.

The practice with this piece exhibited such great lateral dispersion that it cannot be considered satisfactory. The recoil, too, was most difficult to control, though this difficulty is capable of being easily remedied by fitting the carriage with a hydraulic buffer.

The weight of the maximum charge was 7 lbs., that of the shell 64 lbs.

Hydro-Pneumatic Carriage 6·6-inch R.M.L Gun of 70 Cwt.

In this carriage, which weighs about 51 cwt., the mode of construction adopted for enabling the force of recoil to be stored up within the cylinder on firing, so that it may be utilised for again raising the gun into the firing position after loading, may be described as follows :—



The diagram represents the ram R forced out to the full extent as when the gun is in the firing position.

On firing, the ram R is forced into the cylinder B; the pressure thus exerted, by causing the coned valve E to open outwards, enables the water to escape through it from the inner cylinder B into the outer cylinder A.

In proportion as the water is forced from B into A, so does the level of the water in the latter rise, and consequently the air in the space A A (which has been previously pumped in up to a pressure of about 400 lbs. per square inch) undergoes further and constantly increasing compression, until it exerts a pressure equal to that exerted by the ram, and when this occurs the latter comes to rest.

Directly the ram is brought to rest, the combined pressure of the air and of a spiral spring on the coned valve, E, forces it into its seat, and shuts off the air pressure from the ram.

When it is again desired to raise the gun into the firing position the lever G is turned; this partially withdraws the coned 'by-pass' valve H from its seat, and the pressure of the air being communicated through the medium of the water, acts under the ram and raises the gun into the firing position. The pressure in the cylinder is so regulated as to be about 700 lbs. per square inch when the ram is nearly home in the cylinder, or when, in other words, the gun is in the loading position, and 400 lbs. per square inch when the gun is up in the firing position.

One-third glycerine is mixed with the water to guard agains freezing.

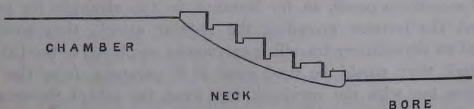
Scoring Shields.

In order to save the inner tube from the erosive action of the powder gas at the neck of the chamber, trial has lately been made of a copper 'scoring shield.'

Brief consideration will show the cause of the destructive action referred to. An immense volume of highly compressed gas is evolved in the chamber at an excessively high temperature, and as soon as the projectile moves from its seat this mass of compressed incandescent gas rushes forcibly forward through the neck of the chamber, where, owing to the comparatively sudden contraction, the gas necessarily acts with a concentrated force, which tends to eat out the steel in long scorings, running fore and aft. Scorings of the nature indicated are especially liable to increase rapidly in size and depth, and to initiate a splitting action, which, of course, it is most important to avoid. As long as the movement of the gas is parallel to the surface of the chamber or bore, it appears to flow over the metal innocuously, and it is only when it meets with metal inclined to its course, or is forced to rush through a contracted passage, that its action becomes decidedly destructive.

To guard against this destructive action, copper 'scoring shields' have been tried with promising results.

The diagram shows the form of shield adopted: it is driven into the grooves in the tube by means of mandrils.

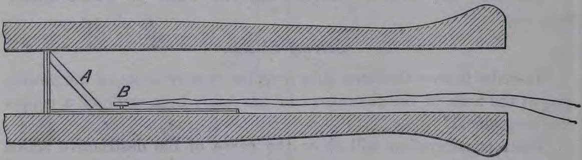


Section through 'Scoring Shield.'

Examination of Guns by means of Electric Light.

An ingenious plan has been lately devised, by means of which any part of the bore of a gun can not only be thoroughly examined, but also be photographed.

A copper cylinder, with the upper half removed, is made to fit the bore, and to carry a mirror, A, inclined at 45° to the axis: this mirror, on being illuminated by an electric light fixed at its base, B, reflects an image of the desired part of the bore to an observer at the muzzle: the image so reflected can be photographed if desired.



Siege Carriages.

The subjoined table shows the various pieces at present in the Siege Train, and the nature of the carriages on which they are mounted:—

Nature of Ordnance.	Nature of Carriage.
6·6-in. R.M.L. Gun, 70-cwt.	Steel, hydro-pneumatic
40-pr. „ „ 35 „	Wrought iron, travelling, with or without overbank tops.
25 „ „ „ 18 „	
8-in. „ Howitzer, 70 „	Wrought iron, travelling, with hydraulic buffer for checking recoil.
6·6 „ „ „ 36 „	
6·3 „ „ „ 18 „	

Gun Carriages.

Gun carriages. When the 40 and 25-pr. guns are used as "guns of position," which would sometimes occur, as, for instance, in the struggle for ground without the fortress preceding the regular attack, they would be worked on the ordinary travelling carriages; employed in the batteries of attack they would be fired over 5′ 8″ parapets, from the same carriages, but with the overbank tops fixed, the axis of the trunnions being thus raised to a height of 6′ 3″ above the platform.

The main disadvantage of a fixed overbank system is, that the gun, unless screened, presents an ever-present target for the enemy's fire.

The 40 and 25-pr. guns are now being fitted with French's sights, on one side, so as to enable them to be laid "reverse" from screened positions.

The recoil of these pieces is checked by the slope, 3°, of the Clerks' platforms from which they are fired. 40 and 25-pr.

Travelling siege carriages are furnished with travelling trunnion holes: the object of which is to distribute the weight more evenly between the gun and limber wheels.

The 25-pr. carriage is of Heavy Field pattern, and has no travelling trunnion holes. In this carriage the height of the axis of the trunnions is 3′ 10″.

The 5-in. B.L. gun (intended ultimately to replace the 40-pr.) is mounted on a Steel Lattice-girder overbank carriage, fitted with a hydraulic buffer secured in a circular opening in the axletree of the gun carriage. This buffer is inclined downwards at an angle of about 30° to an anchorage in the parapet, so that it exercises a holding-down influence, and restrains the jump of the system on firing. 5-in. B.L. gun of 36 cwt.

The anchorage is laid like an ordinary howitzer anchorage, but the iron tie-rod is prevented from rising by a beam being laid over it just inside the interior slope of the parapet.

These carriages are made to fire over a 6′ parapet.

On account of the large charges used with this and with the 6·6-in. R.M.L. gun (16 and 25 lbs. P. respectively), it is necessary to specially protect the superior slope from the effects of the blast; this is effected by employing 3 or 4 "Hides-ox-sundried," in each of which about six filled sand bags are placed, after which the hide is sewn or laced up so as to form, as it were, a large portmanteau. These large bales are set in the superior slope, one in front of the other in the line of the blast, from the interior crest outwards, and have been found to answer very well.

The 6·6-in. R.M.L. gun is mounted on a steel hydro-pneumatic carriage, the action of which has previously been explained. It is capable of firing over an 8′ parapet.

The special advantages of this system are:—

"a." The large amount of cover obtained.

"b." The small amount of manual labour required to serve the gun.

"c." The short time the gun is exposed, *i.e.*, is in the "firing position."

On the other hand, the disadvantages are:—

"a." The unavoidable complications of the hydro-pneumatic system.

"b." The necessity for making large and deep excavations for the anchorages.

The carriage with cylinder weighs 51 cwt.

Howitzer Carriages.

Howitzer Carriages 8-in., 6 6-in., and 6·3-in.

The travelling carriages on which these pieces are mounted raise the axis of the trunnions to a height of 4′ 5″ abovn the wood ground-platform on which they are worked.

The howitzers are fired through counter-sloping scoops in the parapet, the laying being "reverse," by means of French's sights.

The recoil is restrained by means of the hydraulic buffer secured to the carriage and to an anchorage in the parapet, aided by the slope of the platform (1 in 24).

The 6·3-in. howitzer has hitherto been worked on a carriage without a buffer, but the recoil with maximum charges having been found to be inconveniently great, the carriages will, in future issues, be fitted with buffers; the same carriage will then be suitable for either the 6·6 or 6·3-in. howitzer.

The following are the weights of the siege train carriages:—

Weights of Carriages.

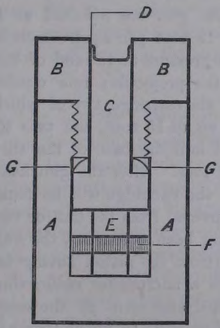
Nature of Ordnance.	Weight of Carriage.	Weight Top of (O.B.)	Total.	Remarks.
	cwt.	cwt.	Cwt.	
40-pr. R.M.L. Gun ..	$33\frac{1}{2}$	$9\frac{1}{2}$	43	
25-pr. " " ..	$19\frac{1}{2}$	$7\frac{3}{4}$	$27\frac{1}{4}$	
6·6-in. " " ..	51	—	51	H.P. steel.
5-in. B.L. Gun, 36 cwt.	30	—	30	Lattice-girder steel.
8-in. R.M.L. howitzer	45	—	45	With buffer and brake.*
6·6-in. " " 6·3-in. " "	$36\frac{1}{2}$	—	$36\frac{1}{2}$	With buffer.

* This is a travelling brake fitted to the wheels, which is removed before the howitzer is placed in battery.

Crusher Gauge.

The instrument employed for ascertaining the maximum pressure exerted by the powder gas at any desired point in the bore of a gun is called a crusher gauge.

It consists of a steel cylinder, A A, having a screwed-in removable head, B B.



Inside the steel cylinder is placed the small copper cylinder E, which is held in position by the watch spring F in such a way as not to interfere with its expansion laterally; resting on the copper is the steel piston C, held in position by the spring, G G. The removable head, B B, is screwed on, and the small copper gas-check, D, is inserted over the piston to make an air-tight joint.

The external form of the steel cylinder, A A, is made to suit the requirements of the case; *i.e.*, if required to be inserted through the metal of the gun at any particular spot, it is made of the requisite length, and turned with a screw externally, like a vent-bush, to enable it to be screwed into the gun until flush with the inside of the bore.

If intended for insertion in the base of a projectile, it is made like the base plug of a shell; if used at the end of the bore of a M.L. gun, it is sometimes fixed in the centre of a copper cup made to fit the end of the powder chamber.

In order to obtain the pressure at the end of the bore of a B.L. gun, four gauges are placed loose in the powder of the charge in the base of the cartridge.

The method of ascertaining the pressure at the particular point occupied by the gauge is as follows:—A series of cylinders of precisely the same size and shape are cut out of the same sample of prepared copper, and are subjected to a scale of statical pressures in a machine in the Royal Arsenal, and the resulting compressions tabulated. Those intended for use in the gun are selected as follows:—Suppose a maximum pressure of 17 tons per square inch is expected, and it is wished to ascertain the pressure at the end of the bore of a B.L. gun and on the base of the projectile: four crusher gauges would be inserted in the base of the cartridge, two of which had previously had their coppers crushed up to 15 tons, and two to 12 tons; a gauge would also be screwed into the base of the shell whose copper had been crushed up to 12 tons. After the gun has been fired, the four gauges which were in the cartridge will be found lying in the bore. The shell has to be recovered from the butt or range, as the case may be. The coppers having been taken out, the amount of compression they have undergone (from the piston having been forced down on them) is measured with a micrometer scale; then by comparing the result with the tabulated statement of the coppers crushed in the machine, the amount of pressure to which they have been subjected is ascertained without any calculation.

The object of previously crushing up the coppers to an extent but little short of the maximum pressure expected is to guard against the piston acquiring *vis viva*, for when this occurs, a pressure in excess of the true statical pressure is recorded.

The extreme simplicity of the instrument, combined with the very accurate results it affords, render it invaluable in proving powder or guns and in experiments; it has now been in almost daily use for a considerable number of years.

Some experimental guns are pierced for crusher gauges at every foot of their length from the end of the bore to the muzzle.

The following example of maximum pressures thus obtained may prove of interest.*

* A is the crusher gauge at the end of the bore; the other gauges being 1, 2, 3, &c., feet respectively from the end of the bore up to the muzzle.

TABLE B.

Gun.	Calibre, inches.	Charge, lbs.	Projectile.	Pressure in tons per square inch.															
				A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
38-ton	12·5	130 P^2	800 lb.	21·5	22·6	22·8	19·2	13·2	9·5	6·3	4·0	2·8	2·9	2·4	2·1	1·4	1·3	1·1	1·0

It is worthy of note that the maximum pressure exerted on the base of the projectile generally falls somewhat short of that at the end of the bore, owing to the shot being on the move before the maximum pressure is reached.

*The "Le Bouleingé" Chronograph.**

THE instrument now used for taking muzzle velocities is that invented by Major Le Bouleingé, of the Belgian Artillery, who, in common with all successful inventors of instruments for accurately measuring the velocity of projectiles, makes use of electricity as his agent.

The instrument consists of a hollow brass column, S, which supports two electro-magnets, A B, and a small bracket, K. The column stands on a triangular base, upon which is fixed the trigger, T.

The electro-magnet, A, supports a long cylindrical rod, C, suspended vertically, and called the 'chronometer.' This rod, which is partially covered with two zinc tubes, D E, called 'registers,' falls on the first screen being cut.

The electro-magnet, B, sustains a shorter rod, F, named the 'registrar.'

The trigger consists of a circular steel knife, G (see Pl. V. fig. 1), fixed in a recess of the spring, H, by means of the screw, N, which forms an axle upon which it can be turned so as to bring a fresh portion of the edge opposite the chronometer.

The spring, H, can be cocked or restrained by means of the catch on one end of the lever, I.

The other end of this lever carries a disc, O, fixed to a screw, by means of which it can be raised or lowered as required. This disc is vertically below the registrar when suspended from its electro-magnet, consequently when the current through the second screen is broken, the registrar falls on the disc and releases the spring, H.

The tube, L, retains the registrar after its fall.

* This account of the instrument is extracted nearly verbatim from a description written by Captain C. Jones, late R.A.

If it be required to alter the time taken by the registrar to release the knife, it is done by screwing the disc up or down; if screwed up, the distance between the disc and the rod being lessened, the time is diminished, and *vice versâ*.

The arrangement of the screens, &c., &c., is shown in Plate VI.

The disjunctor (see Pl. V. fig. 2) is composed of a mainspring, t, carrying a cross-piece, u, covered with insulating material, and passing under the two steel plates, q, q'. By pressing the mill headed screw, z, the spring is compressed and held by the catch, x, allowing the plates, q, q', to come in contact with the metal pins, r, r', and thus complete the circuits by bringing the screws, s, v, and s', v', into connection with one another.

When the catch, x, is pressed, the mainspring being released, its cross-piece strikes he two plates exactly at the same instant, raises them from the screws, and thus breaks both currents identically at the same time.

The electro-magnet, A, is magnetised by the current passing through the first screen; consequently when the shot cuts this screen the chronometer is released and falls freely in a vertical direction.

The other electro-magnet, B, is in the circuit through the second screen, so that the 'registrar' falls when this screen is cut, and, striking the disc on the free end of the lever of the trigger, liberates the spring, which carries forward the knife until it strikes the 'chronometer' in its fall, and makes an indent in the upper zinc tube.

It is evident that the time which elapses after the fall of the chronometer before the registrar is released is the time taken by the projectile in passing over the distance between the screens; the less, therefore, the velocity of the projectile, the further will the chronometer have fallen, and the higher up on it will be the indent made by the knife.

A graduated rule is used for measuring the height of the indent above the zero point. It is of brass, and is graduated on both edges; the upper edge is a scale of equidistant parts, divided into inches and tenths, reading to thousandths, with a vernier, and is intended for use in connection with the tables.

The lower scale is for reading off the velocity of the projectile without any calculation. It is graduated in feet for a distance between the screens of 120 feet.

The zero point on the scale corresponds with the 'origin,' or the point at which the knife marks the zinc, if the trigger is set in action *when the chronometer is at rest.*

If the suspended rods commenced to fall the instant the screens were cut, and if the indent was made by the knife the instant the shorter rod was released, then the distance of the indent above the 'origin' would afford a correct measure of the time taken by the projectile in traversing the distance between the screens. But this is not so; in fact, after the rupture of the first screen, a certain time elapses before the electro-magnet, A, is demagnetised sufficiently to free the chronometer, and the movement of the chronometer will therefore be delayed.

Again, some time elapses between the cutting of the second screen and the moment when the knife reaches the chronometer, viz., the time required for the following:—

1. For the demagnetisation of the electro-magnet, B, supporting the registrar.
2. For the fall of the registrar on to the disc of the trigger.
3. For the disengagement of the catch of the spring.
4. For the knife to pass over the horizontal distance which separates it from the chronometer.

In order to enable us to eliminate the time thus taken by the instrument in acting, a 'disjunctor reading' is taken. This operation may be described as follows:—

The disjunctor is first cocked, then the trigger, after which the chronometer and registrar are suspended. Then by releasing the catch of the disjunctor, both currents are cut simultaneously, and an indent is obtained on the chronometer corresponding to the time taken by the instrument to act.

On the graduated scale for reading off the velocities is a line marked 'disjunctor,' and if we get the disjunctor reading of the instrument to agree with it, we are enabled, when using the instrument for taking velocities, to read them straight off by the graduated scale.

As explained before, we can alter the length of the 'disjunctor' reading by screwing the disc, O, up or down. We can also, if necessary, alter the strength of the electro-magnets by screwing their soft iron cores in or out.

As a rule, the instrument should be used with the magnets of a strength only just sufficient to support the rods.

To enable the proper strength to be arrived at, a small extra metal cylinder is provided for each rod; these being placed on the rods, the core of the electro-magnets is screwed out until the magnet lets its suspended rod fall; the extra cylinders being then removed, the magnets will be just strong enough to support their respective rods.

The first screen has to be placed at such a distance from the muzzle of the gun as to be secure from the destructive effect of the blast on firing; the second screen is placed at a constant distance of 120 feet from the first; this being the distance for which the graduated scale for reading off the velocities is calculated. The velocity actually obtained is that of the projectile at a point midway between the screens; this is referred to a previously prepared scale from which the velocity at the muzzle is ascertained.

It is a curious fact that, when firing charges of large-grained powder, unless the precaution be taken to erect a canvas screen between the gun and the first screen, its wires are apt to be cut by unconsumed grains of powder *before the shot reaches the screen.* When this occurs, the results obtained are of course untrustworthy.

TABLE OF R.M.L. ORDNANCE, SHOWING MUZZLE VELOCITY, ENERGY, &c., &c.

Ordnance Guns.	Total Length.	Bore Length.	Diameter of Chamber.	Charge.	Weight of Projectile.	Muzzle Velocity.	Muzzle Energy.	Remarks.
	ft. ins.	Calibres.	ins.	lbs.	lbs.	f.s.	f.t.	
17·72-inch 100 tons	32 $7\frac{3}{4}$	20·5	19·7	450 Prism 1 or 2	2,000	1,548	33,233	Charge in four cartridges.
16-inch 80 „ .	26 9	18·0	18·0	450 Prism 1 or 2	1,700	1,604	30,329	Charge in four cartridges.
12·5-inch 38 „ .	19 2	15·8	14·0	210 Prism² .	818	1,546	13,554	Charge in four cartridges.
12-inch 35 „ .	16 3	13·5	—	110 P. .	714	1,300	8,367	
12-inch 25 „ .	15 $2\frac{1}{2}$	12·0	—	85 P. .	614	1,300	7,195	
11-inch 25 „ .	15 0	13·18	—	85 P. .	547	1,315	6,559	
10-inch 18 „ .	15 0	14·55	—	70 P. .	410	1,364	5,288	
9-inch 12 „ .	13 0	13·88	—	50 P. .	258	1,420	3,607	
8-inch 9 „ .	12 0	14·75	—	35 P. .	180	1,413	2,492	
7-inch 7 „ .	12 4	18·0	—	30 P. .	115	1,540	1,890	
				Field Guns.				
				lbs. oz.				
9-pr. 6 cwt. .	6 $2\frac{1}{2}$	22·0	—	1 12 R.L.G.	9	1,390	121	Calibre 3·0 in.

Table of R.M.L. Ordnance, showing Muzzle Velocity, Energy, &c., &c.—*continued.*

Ordnance Guns.		Total Length.	Bore Length.	Diameter of Chamber.	Charge.	Weight of Projectile.	Muzzle Velocity.	Muzzle Energy.	Remarks.
		ft. ins.	Calibres.	ins.	lbs.	lbs.	f.s.	f.t.	
13-pr.	8 tons	7 8	28·0	3·15	3 2 ,, .	13	1,560	221	Calibre 3·0 in.
16-pr.	12 ,, .	6 6	19·0	—	3 0 ,, .	16	1,355	203	,, 3·6 in.
					Siege Guns.				
					lbs.				
25-pr.	18 ,, .	8 2	22·0	—	4 R.L.G. .	25	1,320	302	,, 4·0 in.
40-pr.	35 ,, .	10 0	22·0	—	7 ,, .	40	1,380	528	,, 4·75 in.
6·6-inch	70 ,, .	9 10	14·7	—	25 P. . .	100	1,468	1,495	
					Siege Howitzers.				
					Maximum. lbs.				
6·3-inch	18 ,, .	4 8	7·14	—	4 R.L.G.[2] .	70	950	1,141	
6·6-inch	36 ,, .	7 6½	12·0	—	5 ,, .	100	839	488	
8-inch	70 ,, .	9 5	12·0	—	11½ ,, .	180	778	290	
					Old Pattern Armstrong 40-pr. B.L. Gun.				
					lbs.				
40-pr.	35 ,, .	12 1	22·4	—	5 R.L.G. .	40	1,180	386	,, 4·75 in.

Table of Recently Manufactured B.L. Ordnance, and those in course of Construction, showing Muzzle Velocity, Energy, &c., &c.

Ordnance Calibre and Weight.	Total Length.	Bore Length.	Diameter of Chamber.	Charge.	Weight of Projectile.	Muzzle Velocity.	Muzzle Energy.	Remarks.
	ft. in.	Calibres. *about*	ins.	lbs.	lbs.	f.s. *about*	f.t. *about*	
110-ton 16·25-inch (I.) .	43 8	30	21·125 85″ long.	900 C^2* .	1,800 or 2,000	2,050 for 1,800 projectile.	52,000	
63 „ 13·5-inch (I.) .	38 3	32	18	625 C^2* .	1,250	2,050	36,415	
43 „ 12-inch (I. and II.)	27 4·5	25	16	260 Prism[1] .	714	1,770	14,877	
46 „ 12-inch (IV.) .	34 0	32	16 51″ long.	450 C^2* .	850	2,100	23,569	
26 „ 10-inch (L.S. only at present) . .	28 7·75	32	14 49″ long.	300 C^2* .	500	2,100	15,285	

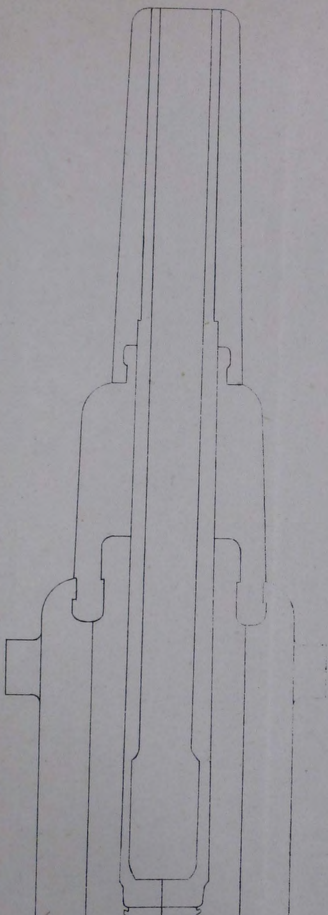
Table of Recently Manufactured B.L. Ordnance, and those in course of Construction, showing Muzzle Velocity, Energy, &c., &c.—*continued.*

Ordnance Calibre and Weight.	Total Length.	Bore Length.	Diameter of Chamber.	Charge.	Weight of Projectile.	Muzzle Velocity.	Muzzle Energy.	Remarks.
	ft. in.	Calibres. *about*	ins.	lbs.	lbs.	f.s. *about*	f.t. *about*	
18-ton 9·2-inch (II.) .	25 10	31·5	12·5	200 C^2* .	380	2,030	10,855	
13 „ 8-inch (IV.) .	21 2½	29·5	10·5 34·5″ long.	100 Prism^1 .	210	2,030	5,998	
89-cwt. 6-inch (III.) .	14 1	26	8 26·8″	42 P^2† .	100	{ 1,870 1,950	2,424 2,635 }	
				Field Guns.				
12 „ 22-pr. (I.) .	9 0	28	4·3 15·15″ long.	7½ P. .	22	1,760	472	
7½ „ 12-pr. (I.) .	7 7½	27½	3·625	4 P. .	12½	1,700	250	
				Siege Guns.				
36 „ 5-inch (II.) .	11 7½	25	5·75 18·8″ long.	16 P. .	50	1,800	1,123	
22 „ 4-inch (III.) .	10 0	27	5·3 18·5″ long.	12 P. .	25	1,950	658	

* Or powder of like nature. † Or 50 lbs. of slow-burning powder.

DERN TYPES OF GUNS.

Pl. I.



DANGERFIELD LITH 22 BEDFORD ST COVENT GARDEN

PAPER XIII.

THE ATTACK ON LISSA, 1866.

Translated from the French by Capt. J. F. Lewis, R.E.

Having experienced considerable difficulty in finding any account of the attack on Lissa, it seems probable that others besides myself might be in the same predicament. I therefore venture to print with a few introductory remarks, a translation which I originally made for my own use.

The operations against the fortifications of Lissa, though now of somewhat ancient date, are still of interest, having been carried out with ironclad ships and rifled guns. Several lessons are to be learned from them.

One is the familiar one of the value of high-level batteries. Neither at San Giorgio nor at Porto Camisa were the high-level batteries silenced by the fire of the fleet.

The necessity of having secure magazines was emphasised by the explosion of two in the batteries.

The undesirability of extending the fortifications more than is absolutely necessary is shown by the intention of the Italian admiral to keep the garrison scattered by attacking all the fortified harbours at the same time. Of course, I do not wish to say that the Austrians in this case unnecessarily extended their defences. If any of their works had been omitted, advantage would very likely have been taken by the Italians to land their troops at the unprotected point.

It will be noticed that the ships fought at short ranges; 300 and 400 metres' range are mentioned.

The entrance of the *Formidabile* into the harbour shows the necessity for submarine mine defences, which would, at the present day, take the place of guns firing on inner waters.

The use of telegraphic communication was shown in enabling the garrison to ask for assistance and to receive news that it was on its way, which must have encouraged them to make a good defence.

The necessity is shown of providing against a landing party. It was evidently impossible to produce sufficient permanent effect against the works by the fire of the ships alone. The batteries that were silenced were able to resume firing when the attack slackened, and several were never silenced at all. It was therefore necessary to endeavour to land troops to attack them.

But the chief lesson to be learnt is the desirability of fighting to the last against a naval attack with whatever appliances may happen to be available.

The Austrians were far outnumbered by the Italians, both in men and guns; and they appeared to have had no guns capable of penetrating the armour of their adversaries' ships. Yet they held out for two days against a vigorous attack, caused the expenditure of a large amount of ammunition and coal, and inflicted sufficient damage on the vessels to have had an appreciable effect on the results of the action that followed with the Austrian fleet.

J. F. L.

14*th March*, 1884.

THE ATTACK BY THE ITALIAN FLEET ON THE ISLAND OF LISSA IN 1866.

Extracts translated from an article by M. L. Buloz, in the 'Revue des Deux Mondes,' July 20, 1866.

THE ITALIAN FLEET.

NAME OF SHIP	CLASS	GUNS, NO. OF	TONNAGE
1. SHIPS ENTIRELY ARMOURED.			
In Wood.			
Rè d'Italia	Frigate, 1st Class	36	5,700
Rè di Portogallo . . .	Do.	36	5,700
In Iron.			
Formidabile	Corvette, 1st Class	20	2,700
Terribile	Do.	20	2,700
2. SHIPS PARTLY ARMOURED.			
In Wood.			
Principe di Carignano . .	Frigate, 2nd Class	22	4,086
In Iron.			
Ancona	Do.	26	4,250
Castelfiardo	Do.	26	4,250
Maria Pia	Do.	26	4,250
San Martino	Do.	26	4,250
Palestro	Gunboat, 1st Class	4	2,000
Varese	Do.	4	2,000
3. TURRET SHIPS (MONITORS).			
Affondatore	Ram . . .	2	4,070
4. UNARMOURED SHIPS.			
7 Frigates	... ...	340 in all	3,400 to 3,980
1 Corvette	... ...	20	1,780
16 Dispatch Boats, &c. . .	... ...	?	?

One thing alone was wanting, but that a very important one, which is not bought, which is not improvised, as we have too well learnt during the wars of the Revolution and of the first Empire, which nations acquire only at the cost of great sacrifices and pains—a sufficiently numerous body of officers imbued (*trémpres*) with a sea life, trained up in, and penetrated with that intimate feeling of discipline, of mutual trust, and of honour, which is the soul of a naval force. The Italian government, if it foresaw an approaching war, ought to have spared nothing to hasten the preparation of this indispensable element of maritime power, without which the others lose almost all their value.

Whilst the Austrians . . . . had only guns of an old type, of which the largest, were smooth bores of a calibre 'of 48,' which only threw solid shot of the weight of 30 kilos. (66 lbs.), a small number of shell guns 'of 60,' and some rifled guns 'of 24,' throwing elongated shot weighing 27 kilos. (60 lbs.), they were absolutely powerless against the armour of the Italian ships, which contained in their armament all the latest improvements which the modern art of war had up to that date invented. The *Rè d'Italia* and the *Rè di Portogallo* each carried two Armstrong guns 'of 300,' 10 shell guns 'of 80,' and 24 guns 'of 30,' hooped and rifled with steel projectiles of 45 kilos. (99 lbs.). The *Formidibile* and *Terribile*, besides their guns 'of 30,' hooped and rifled, were armed with 4 shell guns 'of 80,' hooped, throwing elongated projectiles weighing 60 kilos. (132 lbs.), as were also the other ships.

As to the Monitor with a ram the *Affondatore*, the armament of her turret consisted of two 300-pounder Armstrong guns; and such were the prepossessions in favour of this ship, that when she left the shores of the Channel she was thought capable, alone, of sinking the whole of the Austrian squadron.

The same inequality showed itself again in the construction. The Austrian ships, rudely built, rudely armoured, were only protected by plates, the strongest of which were not over 12 c.m. ($4\frac{3}{4}$-in. thick), and had no ram, for one could not give this name to their cut-water, formed by the meeting of the side plates, which joined with a bevel forward. On the other hand the *Affondatore*, of English construction, had a spur with a projection of 9 m. (29 ft.). The *Rè d'Italia* and the *Rè di Portogallo*, sister ships constructed in America, carried armour 14 c.m. ($5\frac{1}{2}$ in.) on a wood backing of 0·60 m. (24 in.); their stem, although not shaped into a spur, was made of a single forging, and their battery was 2 m. 50 (8 ft.) above the waterline.

The *Formidibile* and the *Terribile*, sister corvettes, came from the workshops of France, had plates of 12 c.m. ($4\frac{3}{4}$ in.) of the best metal on a wood backing of 0 m. 36 (14 in.), with an inner skin of 0·m. 03 (1·2 in.), and carried in front a spur projecting nearly two metres (6 ft. 6 in.) Besides this, they were possessed of considerable speed (12 knots an hour), were broad and short, manœuvred rapidly, and were really formidable instruments of war; all that could be said against them being that they had not enough height of battery.

Let us hasten, however, to indicate the faults that somewhat diminished this omnipotence. The *Rè d'Italia* and the *Rè di Portogallo* then had rudders exposed to fire for a length of two metres, a fatal circumstance which was not, perhaps, unconnected with the loss of the former, and seven other ships were only partially armoured, that is to say, the forward and after part were abandoned to the incendiary appliances of the enemy; and the *Palestro* seems to have fallen a victim to this fatal arrangement.

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Thanks to the revelations of those interested, there was no need to have penetrated into State secrets to divine what passed between the Minister and Admiral Persano. Public outcry made the law—there must be a revenge for Custozza. To the objections of the Admiral that he could count neither on the officers nor the crews, which had hardly been got into shape (*à peine dégrossis*), the minister (Depretis) replied: 'Go, then, and tell the people that in its foolish vanity thinks its sailors the first in the world, that with the 300 millions with which we have overloaded its debt, we have only been able to prepare a squadron incapable of fighting the Austrians! They would stone us! Who has ever spoken of the navy of Austria before but with derision? If Admiral Tegethof refuses to fight, let us try a descent on the coast; let us carry Lissa by a *coup-de-main*. Lissa which is 50 miles to the S.E. of Ancona, by its central position in the Adriatic, will give us the command of that sea.'

To undertake hastily, and without preliminary arrangements, a disembarkation against a fortified position, with the threat of a squadron ready to fall upon him—the very thought made Admiral Persano tremble. It would be necessary for him to disembark a force of at least several thousand men to successfully carry the island and occupy it; but in the midst of the universal intoxication, reason could no longer make itself heard. A peremptory order to act, no matter how, came from the head-quarters of the Army.

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On the 16th July, 1866, at 3 o'clock in the afternoon, without charts, without plans, almost without information on the means of defence of the island, not even yet having the 1,200 troops for disembarking that had been promised him, he (Admiral Persano) got under weigh from Ancona to go and hurriedly make himself master of Lissa. Lissa, the largest of the group of islands that the coast of Dalmatia projects into the Adriatic, is a mountainous mass 15 kilom. ($9\frac{1}{3}$ miles) long by 9 kilom. ($5\frac{3}{5}$ miles) in the greatest width. There are 4,300 inhabitants. Its soil is fairly fertile; the sardine fishery gives it, besides, a certain commercial activity; but it is, above all, as a military position that it is of value. In 1811 a Franco-Italian squadron of eleven ships, under the command of Captain Dubourdieu, struggled for it, but without success, against an English division of four frigates under Commander Hoste. There are still to be seen the tombs of the English officers killed in this combat of six hours, tombs that the Italian bullets have not respected. Its coasts are steep (*accorés*), but there are three anchorages : Porto Camissa on the W., Porto Manego on the S.E., and Porto San Giorgio, two miles to the W. of the N.E. point. This last alone has some importance ; there is the town, formerly a Roman 'oppidum,' with 2,500 inhabitants, at the bottom of a sort of creek extending a mile to the S.W., and half a mile wide, but narrowed by an islet, to not more than 800 mètres (875 yards) at the entrance which is toward the N.N.E.

Admiral Persano took with him, on leaving, only 27 ships ; the rest of the fleet, as well as the troops for disembarkation, were to rejoin him in succession. He sent his chief of the staff, d'Amico, in the despatch boat *Messaggiére* to reconnoitre the strength of the island, and took his course to the north, towards Lossino, until sufficiently far on in the night, in order to deceive the enemy. The *Messaggiére*, under the English flag, fulfilled her mission, and on the 17th, at sunset, met the fleet at the point of rendezvous, announcing that San Giorgio, Porto Camisa, and Porto Manego were fortified and defended by a garrison of from 2,000 to 2,500 men. The Chief of the Staff was of opinion that they had forces enough to make the attempt; Vice-Admiral Albini, who came in the evening to meet the commander-in-chief, endeavoured to dissuade him from it, maintaining that 'Lissa was the Gibraltar of the Adriatic.' Admiral Persano, whose orders were pressing, although he had objected that the troops put at his disposal were not sufficient to take possession of it, decided that they should attack without delay.

At the entrance to the bay on the right hand, Fort San Giorgio and three old Martello towers, built in 1812 by the English, cross their fire with that of a battery en barbette, situated opposite on the left hand ; at the bottom of the port, the powerful casemated battery of the Madonna, supported by other less important work, sweeps the anchorage. Porto Camisa and Porto Manego have only batteries placed on elevated points. The whole of the defence presented a front of nearly 100 guns. The troops, warned (*appelées à l'ordre*) by a signal, thoroughly understood the resolution of their Chief: the Admiral himself with eight armoured frigates would lead the principal attack against the fortified works of San Giorgio. In order to make a diversion, and to occupy the garrison of the island at all points, Vice-Admiral Albini at the head of four wooden frigates would go to Porto Manego to effect a disembarkation there if he could, after having silenced the fire of the battery San Vito which defends it, while Rear-Admiral Vacca, who commanded a division of three armoured frigates, would bombard the batteries of Porto Camisa, and find out if that part of the island did not afford some beach convenient to land on. At the same time Commander Sandri, with four gunboats, would go to Lesina to destroy the telegraph station there which enables Lissa to communicate with Pola. Two dispatch boats placed as scouts on the routes by which the enemy's squadron might come—one to the N.W., the *Exploratore*, the other to the S.W., the *Stella d'Italia*—were to signal the approach of every suspicious ship; finally, a supply ship, and the hospital ship, under the shelter of the island Buso, to the W.S.W. of Lissa, were disposed so as to answer any call. The movement was to begin on the morrow, the 18th July, at daybreak, and, in fact, on that day when, at 11 o'clock in the morning, the frigate *Garibaldi* reached the fleet, all the ships were at their assigned posts, the island was entirely invested, and Rear-Admiral Vacca opened fire against Porto Camisa. Almost at the same time Admiral Persano, who had divided his armoured squadron into two divisions, attacked under steam, from the N. and the S. at the same time, the fortifications of San Giorgio. At this latter place all seemed to go for the best; the parapets and the faces of the rubble walls flew off in fragments at the shock of the hollow shot from the ships; at 1 o'clock the explosion of a magazine blew up the battery at the left of the entrance; then a second went off in the fort on the right, lighting fires here and there. At last, at half-past 3, the flag of Fort San Giorgio was knocked down, the guns, dismounted or deprived of their defenders, were silent, with the exception of two pieces at the telegraph tower, which, too high to be struck by the projectiles from the ships, continued to fire without intermission.

The enemy, however, was not discouraged; as soon as the cannonade of the Italians seemed to slacken, he remounted (*relevait*) his guns, and reopened fire.

One will have an idea, we would not say of the hurry, but of the heat of the action on the part of the fleet, by the fact that the *Ré d'Italia* alone fired 1,300 rounds, and that at a time when she was within 400 mètres of the fort, she threw, in some minutes, 107 Armstrong and other projectiles.

'It was an infernal noise,' wrote on the morrow the Deputy Boggio, the accuracy of whose impressions we do not desire to guarantee. 'Your humble correspondent' (it is the Minister of Marine, Depretis, his friend, whom he addresses), 'remained exposed on the poop of the Admiral's ship from 11 o'clock to 6.30, to a "tempest of shells."' Then, with the same stroke of the pen, he gives a certificate of good conduct and of bravery to Admiral Persano. 'Persano,' he says, 'is unjustly accused. He deserves the entire confidence of the government and of the nation. The heavy responsibility that weighed upon his shoulders might have rendered him beyond measure distrustful; but you, who know in what state the fleet was a week ago, you will do him justice; you will see he knows how to fight. Now that the moment of action is come, what a difference there is between him and others!'

The batteries at the bottom of the harbour kept up a very lively fire; the *Formidabile* received the order to go and bring her broadside to bear at the entrance to the inner anchorage, and the two frigates, *Maria Pia* and *San Martino* to penetrate into it to support her; but at that instant, a little after 3 o'clock, information came to the Commander-in-Chief that Rear-Admiral Vacca, seeing his efforts powerless against the batteries of Porto Camisa, placed too high and out of his reach, had on his own account quitted the position that had been assigned to him, and had joined at Porto Manego the flag of Vice-Admiral Albini. He had already been sent the order to leave at least one of his frigates at Porto Camisa to occupy the defenders, when he was seen to arrive with his division at the entrance Port San Giorgio, where he set himself to cannonade the telegraph tower and the batteries at the bottom of the bay.

A little after, towards 5 o'clock, it was learnt at headquarters that Vice-Admiral Albini had made no attempt on Porto Manego, and the order was sent to him to join the Admiral, the disembarkation having to be carried out at Porto Carober, close to and to the west of the peninsula on which stands fort San Giorgio. These various circumstances having somewhat modified the first arrangements, towards 6 o'clock the signal was hoisted to form line to the front, when Vice-Admiral Vacca came to take up his position, having kept up the fire till then. Soon also appeared the division of Vice-Admiral Albini free from all stain of powder.

One must enter into all these details if one wishes to understand what the Italian fleet was.

Shall we give the name of a council of war to a meeting of officers which took place in the evening on board the *Re d'Italia*, and at which, under the eyes of Deputy Boggio, the same Admiral Persano, who had declared that he had no power against Lissa without an imposing military force, now expressed the intention of renewing the attack during the night, or, at latest, in the morning at daybreak? Captains Morale and Taffini merely remarked that if 1,200 men for disembarkation were taken from the crews alone, they could no longer fight their guns. Nevertheless, the return of Commander Sandri cut short these slight wishes for fighting (*velléités de combat*); the telegraph wires of Lissa were cut, but he had learnt that a dispatch from Admiral Tegethof which had reached the commandant of the island some moments before, contained these words: 'Hold fast till the fleet can come to you.' Under this threat the operation was different. Here, one asks oneself, if Admiral Persano did not feel obliged to play his part before the legislative attaché, as formerly the generals of the Republic before the Commissioners of the Convention, as in our time, in autocratic governments, before certain secret, but not less accredited and dangerous agents.

The next day, 19th July, the monitor *Affondatore*, two screw frigates and a paddle-wheel corvette joined, coming from Brindisi and Ancona with troops, which made the disembarkation corps amount to 2,200 men. The Admiral, disturbed perhaps in his judgment by the exaltation of deputy Boggio, who only thought of 'displaying with the greatest rapidity the glorious banner of Italy on the ruins of the Austrian forts,' flattered himself that by hastening the operations against Lissa he would diminish the chances of being surprised by the enemy's fleet; he therefore ordered, immediately, the unarmoured squadron reinforced by the small gunboats to prepare for the disembarkation in Porto Carober, under the direction of Vice-Admiral Albini; the *Terribile* and *Varese* to occupy the garrison of Porto Camisa; the *Formidabile* to penetrate into the harbour to destroy its batteries; Rear-Admiral Vacca to support with his three frigates the attack of the *Formidabile*; the other armoured ships to place themselves under the Commander-in-Chief to prevent the works of San Giorgio from disturbing the disembarkation in case the enemy had remounted some guns there.

It was half-past 3 when the new attack began.

The *Formidabile*, supported by the *Affondatore*, took up a position at less than 300 mètres from the powerful battery of the

Madonna, which received her with a fire well kept up and well directed, while at the same time other small works attacked her in flank. Rear Admiral Vacca penetrated, indeed for an instant into the harbour; but not being able to manœuvre there, he left again without even attacking the Madonna, which the *Formidabile* entirely masked.

This strong, though not very graceful corvette, after having remained for an hour alone before the battery which she could not reduce, retired, having 55 men *hors de combat*, her rigging cut up, her boats shattered, her nettings partly destroyed, her chimney riddled with splinters of shells, her masts damaged, six port shutters (*mantelets de sabord*), carried away, her deck ploughed by shot and shell; but her armour, notwithstanding the shock of 90 projectiles, remained invulnerable, and (a thing to note), not a shell had penetrated into the battery; one only which exploded on the outer edge of a port, killed two gunners, wounded ten, and filled that part of the battery with such a thick smoke that during several minutes it became impossible to work the guns.

Thus on this side the attack failed, and one cannot tax the Austrians with bragging, when they now boast 'of having driven back the Italian ironclad ships, incapable of resisting the fire of the forts which command the harbour.'

As to the disembarkation—an operation always very delicate, even under favourable circumstances and with well prepared ships—the wind and the sea, the threatening weather, and the approaching night came in the nick of time to give a reason for suspending it. The breeze which all the day had blown from the S.E., that is to say from the land, and was without waves breaking on the shore, freshened considerably at sunset, and, according to the report of Vice-Admiral Albini, brought from the shore a heavy (*demontée*) sea, which rendered the approach difficult. In truth, when one thinks of the confusion which reigned among these badly prepared, badly directed ships, among these undrilled sailors and soldiers, who knowing neither what they had to do, nor whom they should obey, moved about and bustled with that profusion of cries and fiery gestures peculiar to the southern races of Europe; besides that the enemy, in ambush on the beach, had already driven back the advanced guard, and threatened to add a certain inconvenience to the landing. Should not one congratulate Italy that Admiral Persano had not succeeded in throwing hurriedly on shore part of his forces, as he had run the risk of doing? The disembarkation was put off to the next day; half of the companies put on board the gunboats at five o'clock were recalled at seven o'clock, the other half had to pass the night there; and the armoured squadron had the order to keep under steam in line ahead off the roadstead till day.

On the 20th July 1866, an unlucky day henceforth in the annals of Italy, the early dawn brought before Lissa the steamer *Piedmont*, loaded with an entire battalion of marine infantry.

At the sight of this unexpected reinforcement, neither the weather, which became stormy, nor reflection on the peril which became more imminent at every moment of a tremendous attack by the enemy's squadron against his shattered and disordered fleet, nothing could change the resolution of Admiral Persano; he blinded himself to the danger; the telegraphic dispatch of Admiral Tegethof was only to his eyes a ruse of war to turn him from the attack of Lissa; besides, were not his look-out ships there to warn him in time? And then several ships in the fleet had only coal for two days; they had not thought of ensuring a supply for him by transports. It was necessary to act at once, or to return to Ancona to take in coal and warlike stores—of which the ironclads had consumed an enormous quantity in the preceding days. The order was given to the *Terribile* and the *Varese* to recommence bombarding Porto Camisa, to Vice-Admiral Albini to carry out the disembarkation, to the armoured squadron to undertake again the attack of the inner batteries of the harbour.

It was eight o'clock in the morning. These orders were hardly given, when, all at once, the *Exploratore* emerging from a squall to the N.W., appeared with the signal of 'suspicious ships.'

The critical hour was now at last come for Admiral Persano, and in what a state it surprised him! His unarmoured squadron was in the midst of the embarrassment of a disembarkation commencing to be carried out; that is to say, with its launches, boats, and barges [*chaloupes canots et chalands*] afloat; part of its crews and troops away encumbering the gunboats; and with all the internal disorder that such an operation can bring upon ships newly fitted out.

And what would this have been then if the operation of landing had been commenced the evening before, at the beginning of night?

Of his corvette rams, the two most useful of his armour-clads for the battle that was coming on, one, the *Formidabile*, was occupied in transporting her wounded into the hospital ship, and besides, from the damage she had received fifteen hours before, she was hardly in a state to take part in the action; the other, the *Terribile*, out of sight, engaged in a simply diversion at some leagues from her flag, could only arrive late at the fight.

The Admiral did not appear to have realised for an instant the value of these two ships; the power of the shock or blow of the ram escaped his mind. The *Rè di Portogallo* and the *Castelfiardo* signalled injuries to their machinery. The rest, with their engines motionless (*stoppées*) in the anchorage, waited for orders.

Let us sum up all this. The Admiral came to the battle with his crews fatigued, 16 men killed and 95 wounded, several of his ironclads damaged, the *Formidabile hors de combat*, his wooden squadron as well as his gunboats badly prepared to take part in the action, and the rest of his ironclads scattered over a length of 20 kilometres; great disturbance and trouble everywhere.

Then follows an account of the action of Lissa with the Austrian fleet, which ended in the defeat of the Italians with the loss of two ships, the *Rè d'Italia* and the *Palestro.*

J. F. L.

PAPER XIV.

NOTES ON ARABIA PETRÆA AND THE COUNTRY LYING BETWEEN EGYPT AND PALESTINE.

By Colonel Sir Charles Warren, R.E., K.C.M.G.

1. Between the cultivated lands of the Egyptian Delta and the hill country of Palestine extends an arid wilderness, part of which is known as Arabia Petræa; it is also known under the name of the Desert of the Exodus.

2. It is bounded on the North by the Mediterranean Sea, on the South-West by the Gulf of Suez, and on the South-East by the Gulf Akaba and Wady Arabah. It is thinly inhabited by nomadic tribes of Arabs, who, according to their traditions, have come from the South, from Mecca, and who are slowly migrating onward into Africa.

3. The country may roughly be divided for general description into four portions:

a. The semi-fertile portions about the Southern end of Palestine, which have once been cultivated but are now lying waste.

b. The arid table-lands of the Tih.

c. The sandy dunes about the coast of the Mediterranean and Suez Canal.

d. The mountainous district of the Peninsula of Sinai.

a. This is commonly called the 'South Country,' and of it Professor Palmer remarks (page 297, 'The Desert of the Exodus'), 'Half the desert owes its existence to him (the Bedouin); and many a fertile plain, from which he has driven its useful and industrious inhabitants, becomes, in his hands, like the South Country, a parched and barren wilderness.' This South Country, or Negeb, is wholly in Turkish territory; it is the home of the Lehewat, the Amarin, the Azazimeh, the Jehalin, and part of the Teyahah. It was once a well-cultivated land, and the ruins of the vineyards and terraces on the slope of the hills are still visible. This country is an artificial desert; it was not visited, and will not be further referred to.

b. The desert of the Tih is a limestone plateau, and is described in general terms in the 'Desert of the Exodus.'

c. The sandy dunes about the sea coast and Suez do not appear to be anywhere described. It is for the most part an undulating waste, covered with blown sand from the sea shore or from the disintegration of sandstone rocks. Its sands are constantly but slowly in motion. In some portions the natural features of the country are very thickly covered with these sands, and only crop out at intervals.

d. The Peninsula of Sinai is described in a variety of works.

4. It is not proposed in the following remarks to make a compilation from other works, but simply to state what may be new or may have been previously incorrectly stated. The very best works contain most erroneous accounts of the Bedouin, and even Professor Palmer was mistaken about the localities they inhabit. It appears never to have been recognised that the tribal grounds are interlaced, and that in many parts detachments of several tribes are found amicably living near the same waters.

5. The desert territorially may be divided into three portions:

A. Turkish Territory.
B. Egyptian Territory East of the Suez Canal.
C. Egyptian Territory West of the Suez Canal.

6. The portion visited lies almost wholly between the Suez Canal and the Eastern Egyptian boundary. This boundary does not appear to have been clearly defined by treaty or otherwise. Several charts show it as a straight line drawn from Al Arish (on the Mediterranean) to Akaba; but, on the one hand, the Porte appears to assume a nominal control over some tribes of Bedouins to the West of this line (in Jebl Hilâl for example); while, on the other hand, the Egyptian territory on the coast of the Mediterranean extends up to Rephia, midway between Al Arish and Gaza. It seems probable that the boundary inland has never yet been demarked, and this uncertainty may at some future period be a source of difficulty leading to a cönflict of jurisdiction.

7. The tribes are located according to the lettering:

Terebin, A.B.C.	Ayeideh, B.C.
Haiwatat, A.B.C.	Towarah, B.
Teyahah, A.B.	Sowârkeh, A.B.
Azazimeh, A.	M'said, B.C.
Alawîn, A.	Turmeilat, C.
Lehewat, A.B.	Mââseh, C.
Bili ben Ali, B.C.	

8. The *Terebin* comprise a very powerful series of tribes, principally living about Gaza, where they are said to number 2,000 fighting men.

Other detached minor tribes live near the Suez Canal, and a powerful tribe lives in the Gizeh district, near Cairo; these tribes are closely connected, but the Egyptian Terebin have, in many instances, almost become Fellahîn. Those who live in Syria are extremely turbulent and fanatical, and are always hostile to Franks. They are said to be very untrustworthy and deceitful. They have a large number of horses and camels, grow corn, and are very wealthy. The Turkish troops quarter themselves among them during harvest time for the purpose of collecting taxes, but are frequently driven out. The Turks generally keep some of their sheikhs in prison as hostages.

The *Haiwatats* comprise also a very powerful series of tribes. They inhabit a large tract of country East of the Gulf of Akaba, and also Wady Arabah, under the name of Alawîn. They also occupy the country between Suez and Akaba, but only in detachments. They occupy the country between Suez and Cairo in great force, and also about Zagazig. During the late war they were ordered to furnish a contingent of 2,000 men to save Cairo from an attack from the direction of Suez.

Sheikh ibn Shedîd belongs to a very wealthy family living close to Cairo, who from their wealth and influence, having obtained the ear of the Egyptian Government, assume a kind of control over all the other Egyptian Bedouins.

The *Azazimeh* live wholly in Turkish territory, to the West of Wady Arabah. They are a turbulent tribe, constantly at war with their neighbours. They have been seldom visited by travellers.

The *Alawîn* are a branch of the Haiwatat, and live in Wady Arabah.

The *Lehewat* live near the Azazimeh; they do not appear to be a formidable tribe. Meter Sofieh, the guide to Professor Palmer's party, belonged to this tribe, but had ceased to live among them.

The *Bili ben Ali* live almost wholly West of the Suez Canal, but there are a few families about Al Arish.

The *Ayeideh* live almost wholly West of the Suez Canal, where they have been driven during the last few years by the Terebin, with whom they have still a blood feud; their lands formerly extended between Jebl Moghara and Ismailia.

The *Towarah* inhabit the desert of Sinai, and keep themselves aloof from other Bedouins; they are very poor, owing to the drying-up of the Peninsula in recent years, caused by cutting down the timber; they are divided into several minor tribes not necessary to mention, as the whole of the fighting men would not number more than 600.

The *Sowârkeh* are said to be a powerful tribe; they live about Al Arish, and have horses. To all appearances they are a poor tribe. They carried on a successful war with the Terebin for many years, with whom they have a blood feud.

The *M'said* are a poor tribe inhabiting the Suez Canal on both sides, near Kantara; they are a branch of the Lehewat.

The *Tumeilat* live on the West of the Canal, about the Wady Tumeilat. Their Sheikh Ibrahim is a man of some weight among the Bedouins, though his tribe is not of much account.

The *Màâseh* live in the mountains West of Suez; they are well-known marauders, and often travel several hundred miles in their looting expeditions. They are the finest of the Egyptian Bedouins, and would make magnificent soldiers if brought into tolerable discipline.

The *Teyahah* are a powerful tribe inhabiting the Desert of the Tih and 'South Country'; they are a very warlike tribe, and are, in many cases, well-disposed towards Franks; they have been in the habit of conducting tourists through their country from Nuckel to Gaza.

9. The number of fighting men between the Suez Canal and Palestine has been very erroneously computed, having been often stated as 50,000 to 80,000; at the very highest estimate it is not likely to be more than 10,000, and of these a large number must always remain on the lands to guard the flocks.

The Peninsula of Sinai.

10. The Peninsula of Sinai is described in the 'Ordnance Survey of Sinai,' and in Professor Palmer's 'Desert of the Exodus.'

The Plateau of the Tih, rising to an altitude of 4,000 feet above the sea, projects into the Peninsula, and terminates abruptly in a limestone wall 1,500 feet in height, overhanging the sandy plains of Er Ramleh. This sandy plain is probably formed by the disintegration of the sandstone underlying the limestone.

Wherever the strata of sedimentary rocks were observed near the granite walls of the Peninsula, they were seen to have this horizontal position, and gradually become more and more tilted up as they approached the granite. It appears, therefore, to be probable that the sandstone and limestone formations, once overlying the granite, have been removed by denudation.

11. The granite and other volcanic rocks, which now constitute the greater portion of the Peninsula, have evidently been filled in to some extent with sedimentary deposits, which again have for the most part been subsequently cleared out. In some cases the deposit, which is of a marly nature, has not quite been removed, and still fills up the lower

portions of the valleys. It is to be seen in the Wady Feirân, Hebran, Ghurundel, &c.; and in all these valleys springs of water are to be found, as the rainfall cannot penetrate the marly floor, and has to run along its surface to the sea.

In other instances, where this deposit has disappeared and loose sand has replaced it, there is no water to be found.

The rainfall in the Peninsula is at the present time considerably less than it is in the Desert of the Tih, and the drought is excessive. This drought is ascribed to the gradual decrease of the trees—a decrease which has been going on steadily for the last thirty years, since the Egyptian Government imposed a tax of charcoal upon the Bedouins.

Should the Government alter this tax for one which would induce the Bedouin to grow trees, such as a tax of so many muids of dates, it is probable that trees would again flourish in the Peninsula. The cutting down of trees for charcoal should be prohibited, except in districts where trees are over-abundant and require thinning.

12. I was shown many places in the valleys where there had formerly been mazaireh (cultivated ground), but which have now been abandoned for years on account of the drought. In these plaees there were still existing the corn magazines and watch-houses, and the portion of the ground that had been subject to the plough was distinctly visible.

13. There are extensive palm-groves in the Wady Feirân and at Tor. Every Bedouin family has its garden of palm-trees. The fruit serves for food for the human beings, while the date-stones are boiled down for the goats.

There are several places in the Peninsula where the water might be dammed or stored up, but there are not such facilities for this here as in the Tih.

14. The Peninsula is principally inhabited by Towarah, but there are also a few families of Terebîn, Haiwatats, Debûr, and Genounheh. They are all very poor. The Towarah are industrious, and are so poor that they have to eke out their living by driving camels for hire, and go into Egypt to act as servants in gardens. They have much work in connection with the Convent of Sinai, and see so much of tourists in the Peninsula, that they have less active prejudices against Franks than other Bedouins, and consequently are looked upon with doubt and suspicion by their neighbours.

In time of war they are not in the least likely to side with Christians, unless they are sure they are likely to be their future masters. The remark of the Bedouin is a very natural one: it is, 'If I do anything for you openly, what is to become of me when I lose your protection?' The Towarah are not a warlike race, but they would defend their own mountain passes against great odds, or they might fight in the open in a fit of enthusiasm.

About the year 1869–70 they were ordered to assist in guarding the new Suez Canal; but Musa Nuseir, their head Sheikh, refused to do so, on the grounds that the Towarah had nothing to do with the country about the Canal, as they lived beyond it. He was cast into prison on this account, and remained there several months, but eventually succeeded in proving his assertion, and was released.

The Towarah do not now contribute towards the safety of the Canal in any way. It appears that there are very ancient archives in the bureau at Cairo, from which Musa Nuseir proved his case.

15. Musa Nuseir is the hereditary chief of a tribe, and is also Sheikh of all the Sheikhs of the Towarahs, but he is not the Sheikh of all the Towarahs. There is none! He has very little active power among the Bedouins, but he is a singularly upright and honest man, and exercises a strong moral influence upon the people by his good example and straightforwardness.

It is often stated in books that Musa Nuseir is the chief Sheikh in the desert: this is a very grave error. He has no power whatever among the Terebin, Haiwatat, Teyahah, &c., though his opinion as a councillor in the assembly of Sheikhs would be very highly esteemed. Personal influence goes a great way among these people, but intrigue counteracts it.

In such a case as the recent war, when sentiment ruled the Bedouin, the common-sense arguments of Musa Nuseir would be voted as ridiculous and out of place.

He is said during the war to have exercised some considerable control over the Towarah, and to have prevented their breaking out and sacking Tor. It is probable that his arguments among his own particular tribe may have acted as a wholesome check, but there is little doubt that Tor would have been sacked by the Towarah had not preparations been made for the defence at the proper time. Many of the Towarah took more heed of the messages of Arabi, sent through the Haiwatats, than of the arguments of Musa Nuseir.

The Tih.

16. The plateau of the Tih, or Desert of the Wanderings, rises to a height of 4,000 feet above the sea at its Southern end, and slopes down gently towards the North until it is lost in the sandy dunes fringing the Mediterranean coast.

It is formed of nearly horizontal strata of limestone, but here and there is found a fault, when sandstone is visible. The Tih consists of one vast plain, intersected towards the South by deep fissures, and is broken in places with mountain ranges, the principal of which are Jebls Raha, Bodieh, Moghara, Yeleg, and Hilal.

17. The soil and vegetation of the Tih is very variable. There are many places where, for eight or ten miles at a stretch, the ground is hard like rock, and covered with pieces of broken flint, without a scrap of vegetation of any kind. In other places the ground is for miles as smooth as a bowling alley, with a hard, compact white surface, with no place for vegetation. In other parts there are stretches of hard sand, with scanty shrubs here and there.

But traversing all these there are to be found, at intervals, broad, shallow water-courses called *seils*. These are in many cases 100 yards or more wide, and in them are to be found shrubs all the year round, and after heavy rains the grass springs up in them and there is good pasture for several weeks for camels, sheep, and goats.

These seils are very slightly depressed below the general surface of the ground, and, when the rain falls, they present the appearance of broad rivers, 100 yards across, and from one to four feet deep. These waters might be run into dams, as is done in South Africa, and kept for summer use.

18. The so-called *River of Egypt*, or Wady al Arish, is a large seil commencing at the Southern end of the Tih, and running a course of about 150 miles before it enters the Mediterranean near Al Arish. This river is, as a rule, a dry and shallow water-course; but at times, for a few hours, it is quite full of water to a depth of three to four feet. The beds of the large seils are very uneven, and the water will lie in the pot-holes for some weeks after heavy rains. Generally in January and February there is plenty of rain over the Tih—so much so that water for drinking, both for man and for herds, can be found every few miles in the plain, and all over the hills. During November, December, and March, there are often dense mists, moist fogs, and heavy dews, which saturate the shrubs with moisture, and even deposit moisture among the rocks, so that flocks do not require to go to water. These mists depend upon the wind, and often alternate with intense droughts.

19. The rainfall may perhaps be roughly estimated as 12 inches per annum, and appears to be considerably in excess of many of the pasture lands of South Africa. In fact, a great portion even of the desert proper only differs in degree from the sheep farms of South Africa. It will always remain more or less a desert at certain times

of the year, but it is a desert which might with advantage be inhabited by farmers with settled homes.

20. There are very few springs in the Tih, and during the summer the Bedouins are often in great straits for water. The principal permanent springs may be enumerated.

Along the Western edge of the Tih platform, Marbrook, Moses Wells, Wady Sudur, Elifih, Ghurundel.

In the Sinai Peninsula, the springs about Sinai: Wady Feiran, Hebran, and Tor.

The springs in the Wady Al Arish: springs at Moghara, and in the sand dunes about Mahada and Gatieh, where there is fresh water near the surface over a stretch of several square miles.

21. As it is known that there are not only goats, but also a great number of sheep in the desert, it is obvious that there must be food for them. Sheep do not thrive during the hot weather, and at that time are not found to be such good mutton as goat. These sheep are of a very hardy nature, and ewes great with young have been known to travel 30 miles a day for four days without injury. When on the line of march, they generally first suffer from abrasion of their heavy tails.

The price asked for a sheep in the desert is four times that asked in the Jordan Valley, and they often cannot be obtained under 25 to 30 shillings. This excessive price indicates that there is a difficulty in rearing them. During the time we were in the desert, from September to March, we were not able to obtain any milk from the goats or sheep, except during the last month. In Palestine the sheep give milk during the winter.

There are no cattle of any kind in the desert. The only domestic animals seen were—sheep, goats, dogs, donkeys, camels, and horses. The latter are only found in the pasture lands between Al Alrish and Gaza, and towards the South Country. Horses can be taken all over the desert, provided camels are taken with them with a supply of water.

22. The Bedouins congregate together during the summer and autumn, near the springs of water and palm-groves. In the spring they have grass and water everywhere, and are free to go where they like. In the winter they are in great straits, for they have to go where they can find herbage, and yet have to drive their flocks to water, sometimes a distance of 20 or more miles. This they do about twice a week, sending the camels for water for their camp when they have quite run out of water.

When visiting camps, it was not unusual for Bedouins to show that they had not a drop of water even for making coffee until the arrival of their camels, and I have sometimes found it necessary to provide the water for making their coffee, which, however, they have always scrupulously offered to return as soon as they have been enabled to do so

23. It is quite a mistake to suppose that the Bedouins of this desert do not grow corn. Each tribe has its cultivated land (as well as its palm-groves), and they grow as much corn as they require for their sustenance. There are extensive Mazeirah in Wady Er Raj, on the Tih itself, and in various out-of-the-way places which travellers do not see.

Near Wady Sudur, on the summit of Jebl Rahah, at a height of 2,290 feet, is a large tract of Mazeirah, on which the Dubur and Terebin grow their corn. This spot is chosen, both because the soil is fertile and because the sea breezes, charged with moisture, deposit water, in the form of rain or mists, on the high grounds early in the morning. In other cases the Bedouins have joint lands with the fellahên living on the outskirts of the occupied lands of Egypt and Palestine. A family or portion of a family of Bedouins will go a hundred miles or more, quite beyond the tribe, to cultivate land for corn.

The connection of the tribes one with another is difficult for Europeans to comprehend; it seems so contrary to the whole rules of Bedouin life as usually laid down. All the desert tribes have their allies or relations among the Bedouins or fellahên in the cultivated portions of Palestine and Egypt. For example, the Aligat tribe of the Towarah are allied by marriage with the Nifiat of the Nile. No doubt this was at first dictated by policy in order to secure themselves friends respectively in the desert or cultivated country; but it cuts both ways, and anybody who takes the trouble to investigate and understand these relationships will find it comparatively easy to make arrangements with tribes in the desert, however far they may be. In fact, with a reliable Government in Egypt and Palestine, the desert ought to be a safer place for life or property than any large European town possibly can be.

The Sandy Dunes about the Coast of the Mediterranean and Suez Canal.

24. These dunes are gradually sweeping onwards, and have already engulphed the old pasture lands of Goshen. They are caused, for the most part, by the blown-sands of the sea shore, which are constantly moved inland by the prevailing wind.

The process is as follows: The sand, when blown inland from the sea shore, moves forward slowly in a succession of small waves, about one and a half inches from crest to crest. Each wave has a gentle slope of about 10° towards the direction of the wind, while on the lee side it has an abrupt slope of about 30°. Each grain of sand is blown up the gentle slope, and falls by its own weight down the steep slope; thus the waves themselves have a small progressive motion. These small waves, from one cause or another, accumulate into large waves, which in some instances rise to the height of 300 to 400 feet. These large waves, like the small ones, have a gentle slope towards the wind, and a steep slope away from the wind. The sand falling down the steep slope at certain times makes a peculiar musical note from the vibration of the particles. These large sand waves or dunes are continually in motion. The motion is rendered very conspicuous owing to the effect it has on the telegraph line between Kantara and Al Arish. Telegraph poles placed near, or in the hollows, soon get covered up if not constantly moved, and those towards the crests of the dunes are left suspended in the air. The palm-trees at Gatieh, in the same manner, are covered up for a while, and subsequently exposed. The shifting dunes extend inland from the sea to a distance of from 50 to 80 miles, as far as Jebl Yeleg and Jebl Hilal, and are only arrested in their onward course by the mountain ranges. In some cases the outlines of these ranges, as in Jebl Raha, are quite covered up.

There cannot be any extensive growth of shrubs on sand so continually shifting, and there can be no springs of water, with certain exceptions, which I will mention. The district of these sand dunes is looked upon with a certain amount of awe by the Bedouins, who rarely traverse it during the hot months, as water is so scarce, and there is danger if they lose their way.

The exceptional springs are those such as at Mahada, about 30 miles from Ismailia, which have been preserved in a remarkable manner. They are the old springs which were in use many hundreds, probably thousands, of years ago—possibly the springs used by the children of Israel living in Goshen. As the sands encroached, the shepherds using these springs have carried the sand away from their immediate neighbourhood, and this going on for hundreds of years has resulted in craters in the sand 300 to 400 feet deep, at the bottom of which the springs are found.

The land of Goshen is thus engulphed by the sand dunes, but it is there still underneath the sand, and fertile as in days gone by.

About Gatieh, between Ismailia and Lake Serbonis, there is fresh water underneath the soil in many places at a depth of a few feet, and here there are forests of palms, said to number 70,000. These are the property of the various tribes and families inhabiting the desert.

C. W.