THE ROYAL ENGINEERS JOURNAL.—DECEMBER, 1914. Pages 345—400.

THE ROYAL ENGINEERS JOURNAL.

Vol. XX. No. 6. DECEMBER, 1914.

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THE ROYAL ENGINEERS JOURNAL.

VOLUME XX.

JULY TO DECEMBER, 1914.

CHATHAM:
ROYAL ENGINEERS INSTITUTE.
AGENTS AND PRINTERS: W. & J. MACKAY & CO., LTD.

VOLUME XX.

Subject Index.

Original Articles are entered in thick type; Translations, Reviews, and Notices of Magazines in thin type.

Index to Authors.

(Memoirs and Reviews Omitted).

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

R.E. WORK AT THE FRONT.

WE are greatly indebted to Officers of the Corps at the Front for sending reports of the following important R.E. work. Such information is especially valuable at the present moment. We shall gladly welcome any further communications.

(A). REPAIR OF OLD BRIDGE AT ——.

On September 27th one section of the —— Field Company, R.E., was sent to ——.

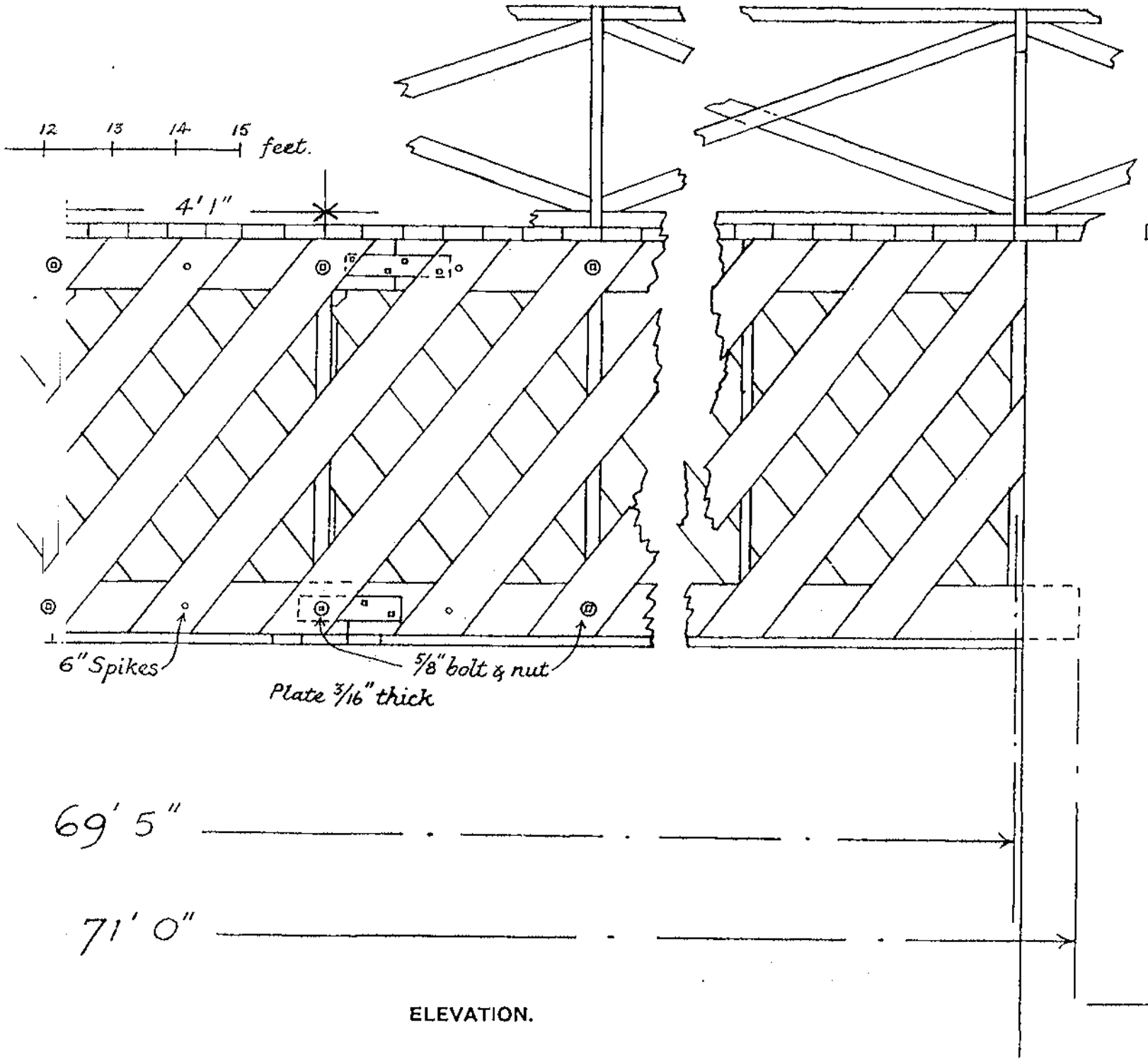
A design was sent in for the repair of the Old Bridge at —— by using wooden lattice-work girders. The bridge consisted of several stone arches, and one large span of iron girders at the south-west end of the bridge. The demolition had been done by the —— in retiring, and a gap of 76 ft. in the clear was left. The height from the roadway to the bottom of the river was 40 ft., so that an intermediate support was almost out of the question. The bridge was designed to take a maximum concentrated load of 10 tons, and four girders were used with thick chesses laid flat on top. The design was accepted, and orders to begin work were received at mid-day on September 30th. The section had been at work the previous night, and only three hours' work was therefore done on the afternoon of September 30th, which consisted chiefly of collecting nails, spikes, bolts, etc., and sorting the timber required for the whole of the work. After this, the work was carried on from daylight to dark, *i.e.* from 6 a.m. to 6 p.m. each day, with one hour off for dinners. The next day, October 1st, one girder was constructed near the bridge under cover behind a row of houses. The enemy shelled the river occasionally with shrapnel throughout the day. The first girder was tested on the afternoon of October 1st; it was packed up at both ends and a platform constructed in the middle, and on this, men to the weight of 2 tons were placed. The girder deflected $\frac{7}{8}$ in. and rose $\frac{1}{2}$ in. when the weight was removed. After this it sank or rose $\frac{1}{2}$ in. each time it was loaded or off loaded.

The next day, October 2nd, two more girders were constructed. The enemy had now practically ceased to shell the river. That night footings were cut for the girders on the centre pier; these consisted of holes about a foot deep, and measuring about 7 in. wide and 10 in. high cut into the face of the stone to receive the ends of the bottom flanges. Charges were also fixed and fired at 3 a.m., to cut off the ends of the broken girder, that would otherwise

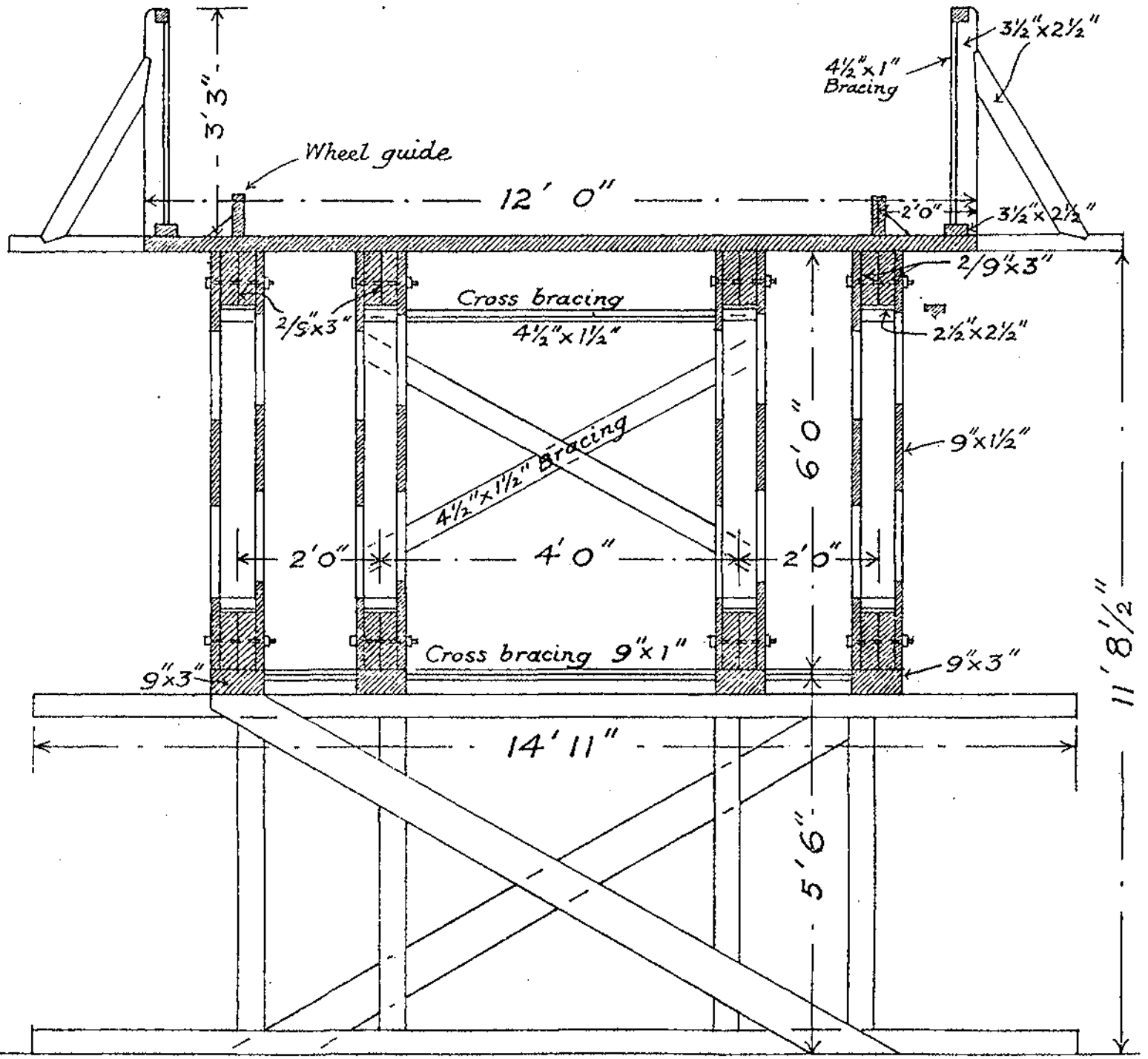
have been in the way. On October 3rd two girders were tested with 7 tons dead concentrated load. The deflection was 1 in. and the girder rose this amount on being off loaded. The fourth girder was then finished and a platform on trestles built up on the towpath to support the girders at the shore end. Shear legs were constructed and everything prepared for launching the girders.

On October 5th we stood by, waiting to hear if the German guns had moved, as our girders would have been a splendid target for them, and would soon have been demolished. Late on October 5th the —— General Commanding the —— Army Corps informed us that the girders could safely be launched, and the work was begun that night and continued and finished on October 6th. They were pushed up to the bridge on rollers. They were then held vertical by side guys and pulled across the gap with a 2½-in. fall and tackle attached to shear legs on the centre pier. The girders weighed about 2 tons and the working party only numbered 28, so that great care had to be taken, especially as the girders had very little lateral strength. The cross-bracing between the girders was commenced the next day, October 7th. It consisted of lateral bracing under all four girders, and between the top flanges of the centre girders. The roadway was spiked on at the same time and consisted simply of 7-in. × 2½-in. deals, laid on top of all four girders; this made a 12-ft. roadway with wheel guides 8 ft. apart to keep the vehicles over the girders. The bridge was completed except for the handrails and a few details, by 6 p.m. that night. When heavy vehicles passed over the bridge it trembled slightly but did not sway. The handrail was finished on the morning of October 8th.

The total working time taken was 61 hours, exclusive of the time taken to finish off the handrail.

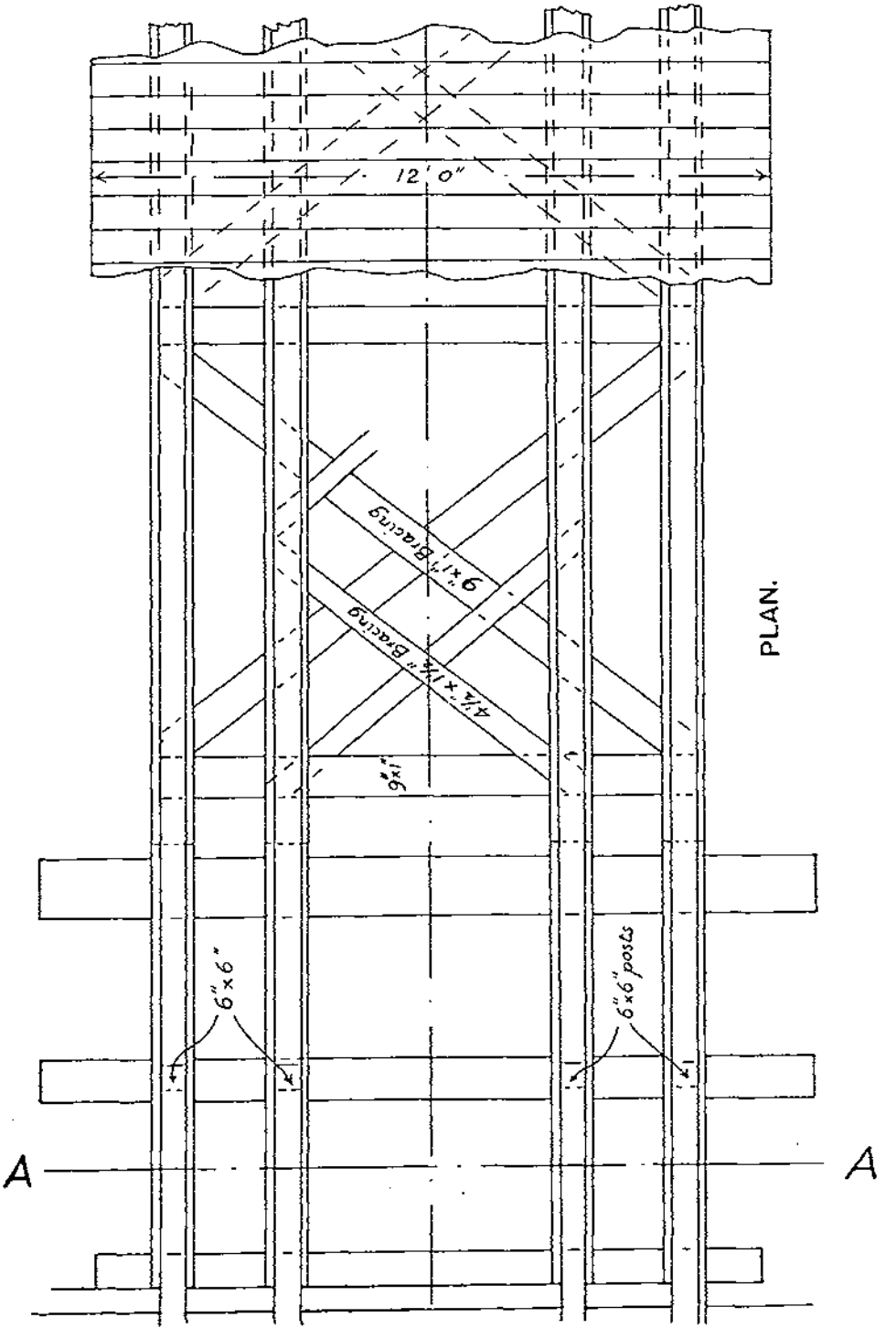


ELEVATION.



SECTION AA.

(A). REPAIR OF OLD BRIDGE AT ——



(B). BRIDGE AT ——.

The bridge at —— over the —— consisted of two 7-ft. iron girders with a central support on a masonry pier, the spans on either side being 90 ft. When the —— Division arrived at —— they found that an attempt had been made to cut these girders at a point 30 ft. from the south end of the bridge; every flange and all the web had been cut except the lower flange on the west side of the bridge, where the charge had failed. The charge consisted of tonite and was detached, and dropped into the river. The bridge was now held up by one flange and the roadway which was reinforced concrete. The infantry crossed in file, and the bridge swayed considerably. The —— Company, R.E., then placed some wedge-shaped stones in the break of both compression flanges, and as the weight came on the bridge the jagged edges of the flanges held these stones firmly and so helped to stiffen the bridge, which was now able to take the field guns which were manhandled over. The next step was to repair the broken tension flange on the east side of the bridge. This was done by tying together two transverse girders with 1-in. tie bars which encircled these girders and were screwed up tight. Three of these ties were used. The wedge-shaped stones were then replaced with channel irons $2\frac{1}{2}$ in. $\times$ 1 in. $\times \frac{1}{4}$ in. which were bolted together through the flanges and cut to such a length that they fitted tight between two stiffeners, as shown in the sketch. The bridge was now able to take all traffic.

In order to further strengthen the bridge rivets were then cut and plates bolted on across the break on all the flanges.

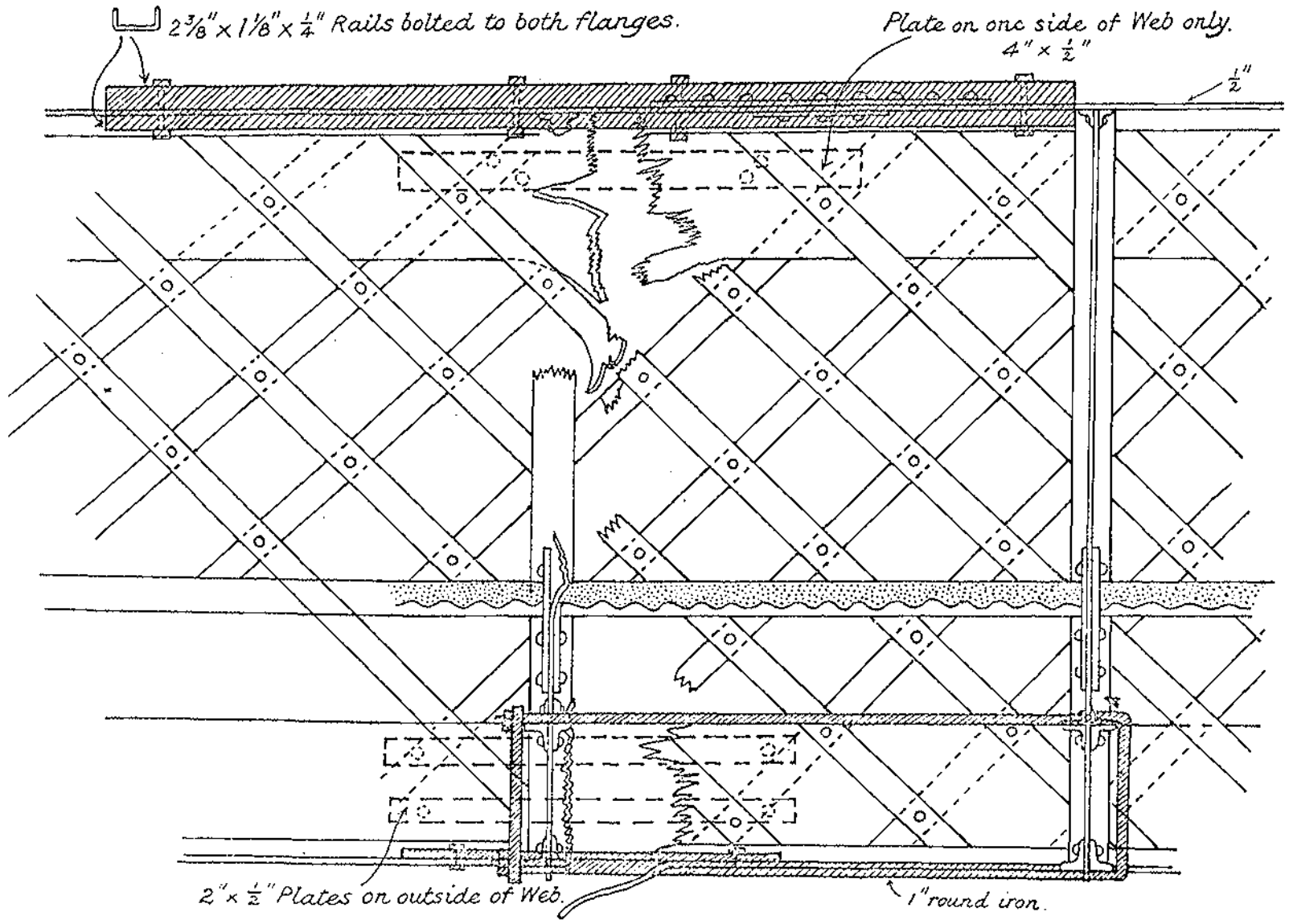
CALCULATIONS.

Assuming that the girder was capable of supporting itself in the position in which it was found, the repairs required were such as to make it strong enough to take say 6 tons live *concentrated* load over the bridge. The maximum bending moment in this case would be $6 \times 1\frac{1}{2} \times \frac{30 \times 60}{90}$ ft.-tons, and the M. of R. is T$\times$6 where T is the maximum stress in the flanges. Hence $T = \frac{9 \times 30 \times 60}{90 \times 6} = 30$ tons. Therefore about 4 square inches of steel should be provided across the break in each flange. In practice about twice this amount was provided.

R.E. WORK AT THE FRONT.

(B). BRIDGE AT ———.

EAST GIRDER.

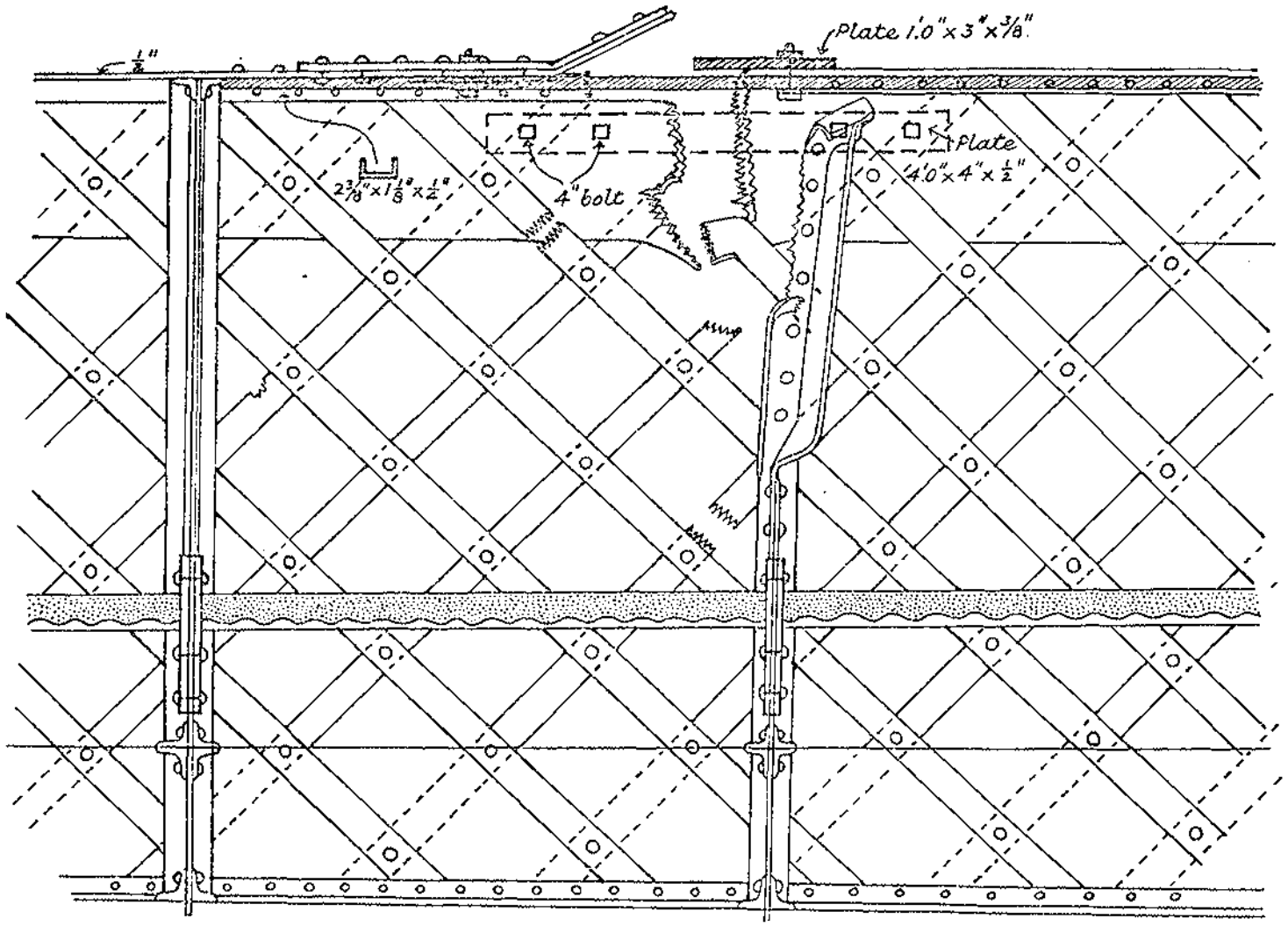


Sectional Elevation on Line A-A.

Scale—$\frac{3}{4}$" = 1'.

All repairs done shaded thus ▨

WEST GIRDER.



Sectional Elevation on Line A-A.
(See Section).

Scale—$\frac{3}{4}$" = 1'.

PLANE TABLES AND FIELD SHEETS.

By Capt. H. St. J. L. Winterbotham, R.E.

In August, 1914, there appeared an interesting paper on the subject of mounting drawing paper on plane tables by Capt. R. H. Phillimore, R.E. The distortion of the "field section" or "field sheet" due to changes of humidity and temperature has been a thorn in the side of the topographer for many years, neither does there appear to be any means of eliminating it as long as paper, linen backed, is mounted upon a wooden board. Some papers do give much better results than others. Messrs. Mallandain & Co., King's House, King Street, London, E.C., supply a linen-backed paper which has been found to give fairly satisfactory results. Distortion is due, however, not only to the unequal expansion of the paper, but to the unequal absorption of moisture by the paste, and to differences of expansion in the wood, with and against the grain.

The solution of the problem given by Capt. R. H. Phillimore is ingenious and the results of the first year's experience will be most interesting.

An adaptation of the same idea was tried during a topographical training on the Ordnance Survey in 1913. Bristol boards slightly smaller in area than the plane table were attached by corner clips which were kept loose enough to allow free play for expansion, except when the plane tabler was actually at work. This system was found to answer fairly well, despite a few cases of "cockling," and made possible the transfer of the Bristol board from the topographer's board to that of the reviser.

In a systematic topographical survey this latter is a great advantage; for it renders unnecessary the number of boards which must otherwise be carried, and enables the plotting of trigonometrical points to be done as long before the detail as may be expedient.

Bristol boards, however, although they generally show no distortion if they are free to move, yet do expand. For reproduction this would not be serious, but for the comparison of mutual edges it remains a drawback. Moreover a Bristol board increases the weight. In view of these two objections experiments were made in 1913 with linen-backed paper mounted on aluminium or zinc. The co-efficients of expansion of both these metals are so small as to be negligible for any ordinary range of temperature.

The points which were aimed at in the production of a mounted field sheet were :—

1. The elimination of distortion and the reduction of expansion as far as possible.

2. Permanency—so that the finished field sheet should constitute a reliable record of the work done.

3. Adaptability to any of the special plane tables designed for it.

4. Lightness.

The two metals have about equal claims under 1, 2, and 3, but aluminium is much the lighter, and its slightly larger cost (8d. as against 4d.) is negligible in comparison to the value of the finished field sheet. Aluminium was therefore chosen. It was at first thought that the actual field work could be done upon a grained aluminium plate, and the experiment was tried. It was not altogether unsuccessful, but the general conclusion come to was that the use of the aluminium surface for field work should be discontinued because

1. It is easily destroyed by dirt, sweat, and rubbed out by pencil.

2. The metal becomes hot to work upon in warm weather.

3. The metal is not easily secured to the table.

Paper can be secured firmly to grained aluminium and the combination remains sensibly constant for normal ranges of temperature, but it was found that the edges curled up enough to interfere with the sight rule.

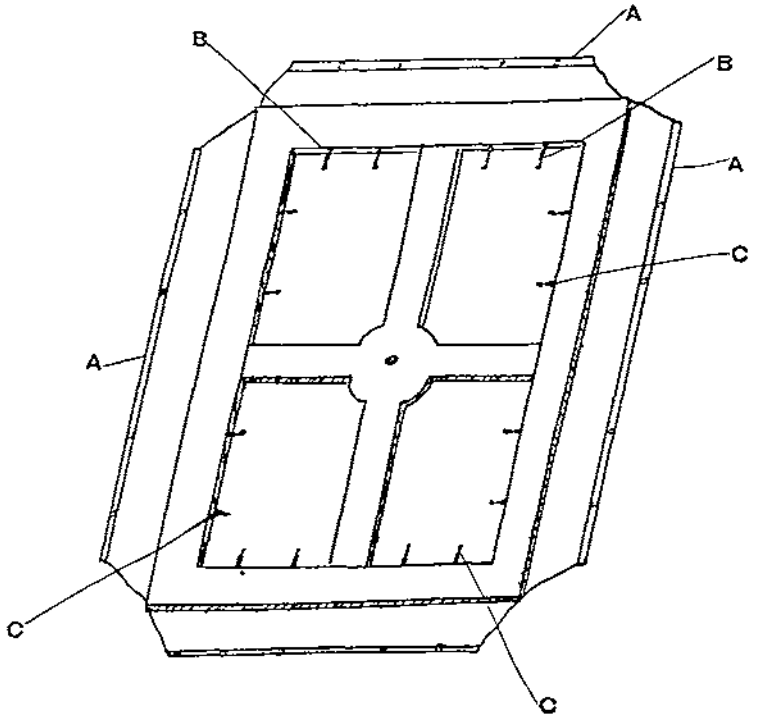
It became necessary therefore to strain the field sheet down upon the table by springs, or lashings, and this was simplified by fixing linen on the aluminium with overlaps projecting beyond all four edges. The paper was then mounted on the linen. Field sheets so constructed have proved satisfactory.

The weight of this field sheet is about 1 lb. more than that of linen-backed paper of sufficient size to mount the board. In some surveys this extra 1 lb. would be a handicap and it seemed possible to save it in the weight of the board. Thirty-gauge aluminium is sufficiently stiff to stand drawing, and the weights of the Indian clinometer and alidade, if it is supported at intervals. A skeleton board was therefore made, and proved to answer very well. It is described on page 116 of the *Text Book of Topographical Surveying*.

The first design was somewhat elaborate, however, and during the first trainings of 1914 experiments have been made to find a simpler pattern. That which proved most satisfactory is described below.

The field sheet is laid on the board ready for fixing and the board is viewed from below.

AA strips of aluminium mounted in the edge of the overlaps of linen and with holes at intervals to fit the BB fixed hooks and CC spring hooks fixed in the depth of the scantling of the skeleton top.



The weight of this board mounted is compared with that of the plane table, R.E., mounted with linen-backed paper, and a Bristol board, respectively, in the following table :—

Description. Size 24 in. × 18 in.	Total Weight.
New board and aluminium field sheet ..	4 lbs. 7½ ozs.
Plane-table, R.E., board with linen-backed paper	4 lbs. 12½ ozs.
Plane-table, R.E., board with Bristol board ..	5 lbs. ½ oz.

The pattern of board described above can be fitted to the legs now in use for the "plane table, R.E." There are however no arrangements for a slow motion in azimuth on these legs. Indeed the feeling of many topographers is averse to the introduction of anything which can be considered elaborate. In those countries where most of our plane-table work is done breakdowns may be fatal. Experiment has proved, however, that a simple but ingenious arrangement can be fitted to the existing pattern of legs which provides a slow motion, thrown in or out of action by a cam, and detachable at will. It has been tried this year and unanimously approved of.

Another small modification which has proved valuable is the introduction of one collapsible leg for each table. They are quite stiff when clamped, add little to the weight, and enable the table to be levelled on steep ground without undue splay of the legs. As each leg is detachable and is generally packed separate from

the "top" the inclusion of a small number of legs of this pattern in the survey outfit will not necessitate their use if found undesirable, but will provide for a possible want.

In the table of weights and prices given below the new type of board is called type A, and the same applies to a set of three legs with slow motion in azimuth and one collapsible leg.

It occasionally happens that topographical work has to be based upon a graphic triangulation, or that the two are done concurrently. In these cases the board has generally to be bigger, and a telescope alidade used with it. For work of this nature a special plane table has been tried with a board of 24-in. square. The field sheet and board are designed on the same principle as described above, but made stronger to support the additional weight of the telescopic alidade. The board is levelled by a ball and socket joint made of aeromin. The importance for graphic triangulation of a field sheet which will maintain its size, not only relatively, but almost absolutely, is self-evident. Experimental work with it has been satisfactory, but trainings this year have been so much interrupted that its use has necessarily been restricted.

In the table of weights and prices this board is referred to as type B.

TABLE OF RELATIVE WEIGHTS AND PRICES.

Description of Table, etc.	Weight.	Price. £ s. d.	Remarks.
Plane table, R.E., complete (without cover)	10 lbs. 12½ ozs.	2 8 10	Priced vocabulary of stores, Part 1.
Type A board with legs of plane table, R.E.	9 lbs. 7½ ozs.	3 0 0 (*a*). 2 17 6 (*b*).	According to quantity— quoted by Messrs. Watts & Son, 123, Camberwell Road, London.
Type A board and legs	11 lbs. 2½ ozs.	3 15 0 (*a*). 3 12 6 (*b*).	
Type B	12 lbs. 8½ ozs	5 12 0 (*a*). 5 7 6 (*b*).	

In conjunction with type A table a new sight rule was tried. The Service pattern is of boxwood. The edges of this pattern are apt to get chipped and broken and in hot and dry climates it warps. Moreover a parallel ruler attachment is of great help to the topographer, as it does away with the necessity of rotation round a fixed point. The new sight rule was of duralumin, and weighed exactly the same as the Service pattern (1 lb. 1½ ozs. in the case). It has a parallel ruler attached and can of course be inscribed with any scale and title. A couple of small level bubbles at right angles to each other can be added and help the initial levelling of the table. Messrs. Watts & Son make it (inclusive of leather case) at a cost of from £2 15s. to £2 12s. 6d. depending on quantity.

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

(Continued).

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

THE SIEGE OF SEBASTOPOL (*continued*).

Vice-Admiral Korniloff was an able administrator and thoroughly understood the duties of a naval commander; but was not gifted with the faculty of designing apt plans for the conduct of the war.

But if the army was wanting in this the time of trial, there had come to Sebastopol, as a guest, a man so gifted by nature as to be able to fill the void; and able moreover to make people bend to his judgment, confessing that his was the guidance which would best meet the emergency; yet, curiously enough, until some four or five weeks before the time of the landing of the Allies, the name of Lieut.-Colonel de Todleben had scarcely been heard of in Sebastopol.

Colonel de Todleben was born in one of the Baltic provinces lying within the dominions of Russia, and to Russia accordingly he had ever devoted himself, but by race, and name, and feature, and warlike quality he was the fellow-countryman of Count Bismarck.

The honour of placing this gifted man on the scene in which he was destined to achieve his renown, must be given to Prince Michael Gortschakoff. Having discovered the capacity of Colonel de Todleben, and knowing how likely it was that the issue of the conflict, which he perceived to be impending, might be governed by a skilful application of the engineer's resources, Prince Gortschakoff determined that he would not only entrust to the colonel the duty of conveying his warnings to the headquarters in the Crimea, but would introduce him to Prince Mentschikoff as an officer capable of being of great use to him in the business of fortification.

Colonel de Todleben was master of the art of military engineering. His devotion to the study of his profession had been unstinted; and there was a period when his practice of the business of mining had kept him underground during a third part of each year. He had great experience in the trenches before Silistria, and the rough tasks of war in the Caucasus. He was about thirty-seven years old.

During the three weeks which elapsed between Colonel de Todleben's arrival and the appearance of the armada on the coast, he was not only making himself acquainted with the field of the approaching conflict, but also beginning to earn that rare confidence, which afterwards enabled him to guide into a right direction the valour and strength of the garrison.

It may truly be said of this colonel of Sappers, all that was fanciful or for any reason unpractical—all that lay, though only by a little, beyond the immediate future with which he was dealing—he utterly drove out of his mind, and his energies, concentrated for the time upon some object to which they could be applied with effect, were brought to bear upon it with all their full volume and power. Under guidance so firm and sure there could be no waste of energy and no waste of bodily labour.

When the Russian field army undertook its flank march, Colonel de Todleben remained at Sebastopol. Admiral Korniloff and he had come to be as one man. They lived in the same room. What de Todleben judged to be right, the Admiral impelled men to do. If Korniloff was the soul of the cause, the great engineer was its mind.

On the 24th September, the day the Allies were marching on the Belbec with the then apparent intention of attacking the Star Fort, Korniloff assumed the command of the North Side and Colonel de Todleben, whilst still continuing to direct the works going on there, was now also charged to post the troops in the way he deemed the best for resisting the expected assault.

Korniloff did not seriously imagine that with the comparatively small force of 11,000 men under his command, he would be able to offer a successful resistance to a resolute attack directed against the Star Fort by a victorious army with a strength of between 50,000 and 60,000 men. Colonel de Todleben did not deceive him and he did not deceive himself. "From the North Side there is no retreat," Korniloff said to Capt. Gendre. All of us who are there will also find our graves. Death does not terrify me. Only one thing makes me uneasy. If wounded, one cannot defend one's self, and to be taken prisoner!"

The morning of the 25th brought with it no signs of the expected advance of the Allies against the Star Fort; but as though to add to the helplessness of the people abandoned in Sebastopol, Prince Mentschikoff had left them without the cavalry required for reconnoitring the enemy; and it seems that the garrison remained unacquainted with the momentous operation in which the Allies were that day engaging, until it was almost noon. Then, strange to say, they learnt the truth without seeking it. From the Naval Library which stood upon a high knoll in the town of Sebastopol and commanded a far-reaching view, some officers extended their gaze towards

a quarter not hitherto thought of as the probable scene of any English or French operations. They looked towards the heights overhanging the head of the roadstead. There, scarlet and glittering under a bright noonday sun, they saw regiments and regiments of the English soldiery moving up along the skirts of the forest to the Mackenzie Heights, and afterwards descending southward into the valley of the Tchernaya. All day, the march was seen going on; and before evening, the heights where the English had first been descried were observed to be alive with dark-coated troops moving on in the same line of march which the scarlet battalions had taken. The import of this movement could hardly be doubtful.

It meant that the Allies were abandoning the valley of the Belbec with design to attack Sebastopol on its south side.

It followed that the Severnaya, which before had been regarded as doomed, was now safe, and that the danger had all at once, shifted from the north to the south of the place.

On the south, the now threatened side, the seamen were commanded by Admiral Nachimoff. Of these for the moment there were few; for out of the battalions already withdrawn from the ships, no less than eleven were on the North Side, and of land forces there were none except the Militia battalions. Nachimoff was a brave, devoted man; but the courage he now evinced was of that forlorn sort which consists of blank despair. By cutting apertures in the ship's sides—to be filled up until the last moment by stoppers—he strove to ensure to himself the power of sending his whole squadron to the bottom with little delay.

Vice-Admiral Korniloff continued to be the "Chief of the Staff" of the Black Sea fleet, and remained in command of his naval squadron; but independently of these functions, the Prince entrusted to Korniloff the command of all the forces, both naval and military, which were to operate on the North Side.

Entrusted with the command of the North Side at the moment when that was the ground believed to be in peril, Korniloff after Lord Raglan's flank march, saw that owing to the Allies so plainly committing themselves to the enterprise of attacking the South Side, the North for the time was comparatively safe.

Korniloff had so much greatness of mind, and was of so generous a nature, that despite the straitening effect of the formalism then predominant in Russia, he was able to understand the occasion. The army, and the commander of all the forces both naval and military, had abandoned the place to its fate. The navy was imprisoned. The peril which beset Sebastopol was great and imminent. On the other hand, Korniloff's orders, if only they were to be obeyed, would prevent him from acting upon the scene of the approaching conflict, and rivet him fast to that North Side which was no longer threatened. Far from accepting the repose thus enjoined by his

instructions, Korniloff at once turned away from the quarter whence the danger had passed, and went straight to where the danger was coming. Giving up the command of the North Side to Capt. Bartenoff, and leaving orders for the transport of his eleven sailor battalions from the North to the South, he went on board the *Twelve Apostles*, in order to consult with Admiral Nachimoff for the defence of the main town and arsenal, now so suddenly threatened; and for the same purpose Korniloff assembled at his lodgings Admiral Nachimoff, General Möller and Colonel de Todleben.

There, arrangements were made for distributing what forces they had along the lines of defence on the South Side. But this was not all that the assembled chiefs did. They came to a great resolve.

Forgetting their mere rank in the army and the navy and remembering only the welfare of their country General Möller and Admiral Nachimoff requested Admiral Korniloff "to undertake the general arrangements for the defence of the town." And Korniloff did not shrink from accepting the command thus proffered him. He observed, it is true, that the land forces would not be under an obligation to obey his orders, but General Möller met this objection by appointing Korniloff the Chief of the Staff of the Sebastopol garrison, and by publishing an instruction which enjoined obedience to all the orders which Korniloff might give the land forces.

The Russians take a just pride in tracing the glory of their defence of Sebastopol to the political courage and the generous self-denial which thus secured unity of command in the gravest hour of danger. Having forbidden the scuttling of the ships as proposed by Admiral Nachimoff, Korniloff with Todleben at his side, devoted his whole energy to the all but desperate purpose of defending the South Side.

The march of the Allies to the south coast was a surprise to the garrison, which had assumed, since the day of the Alma, that the attack would be delivered against the Severnaya, and their energies having been directed in the main to that quarter, they had not found time to do much on the South Side. There, the principal change which had been effected since the landing was the completion of the Central Bastion; and although the lines along the Karabel Suburb were fully equal in their military value to those which took in the main town, they had received but little accession of strength since the day of the landing.

The Battery of the Point had indeed been begun, and preparations had been made for strengthening the position of the Malakoff Tower; but little had hitherto been done to this quarter, and the Malakoff on the 25th September, was a mere naked tower, without a glacis, exposed from head to foot, unsupported by the powerful batteries which were intended to flank it, and uncovered as yet by the works which afterwards closed up round its base.

There were no intermediate entrenchments along the line of the Karabel Suburb to connect with one another the four works either begun or established. These four works afforded but a weak defence to the great intervals of ground by which they were divided. Upon the whole, it may be said that along the arc of 4 miles which encompassed the place on the land side, the part which reached from the Artillery Bay to the Central Bastion was the only one that could be considered tolerably secure.

All the rest of the line of defence, and all the works of the Karabel Faubourg were weak, and could be easily forced. They afforded hardly any cover for infantry, not even for the reserves; and the gunners at the batteries, having for the most part mere barricades to shelter them or having to serve guns which fired over the parapets, would have been ruinously exposed.

To defend this weak line Korniloff had indeed as many artillerymen as he needed; but it seems that the whole number of other combatants that he could employ in the defence of Sebastopol was only 16,000. In this force there was an imperfect battalion of sappers, and a body of 5,000 Militiamen. The rest consisted of seamen withdrawn from the ships, and had been formed into 16 battalions, of which only four were well trained and well armed. The remaining battalions were but slightly instructed in the duties of the land service, and portions of the force were ill armed, some carrying old flint muskets, and some having no better weapons than pikes or cutlasses.

With 16,000 combatants of this description, it was hopeless to try to defend a line of 4 miles against such an attack as might be made by the victorious army of the Allies; and this the more so, since the garrison, split into two by the Man-of-War Harbour and the deep ravine at its head, would be unable to concentrate upon any one endangered quarter this little strength that it had. In the opinion of de Todleben, it was impossible that the attack of the Allies could be repelled by even the most valiant defence.

The 26th, it is true, passed away without showing that the Allies (who had this day seized Balaklava) were preparing an attack for the morrow; but on the other hand it brought no tidings of the invading army. "Of the Prince," writes Korniloff on this day, "nothing is to be heard."

On the morning of the 27th, the garrison was still without tidings of Prince Mentschikoff and his army. "Thus," so Todleben writes, "the defenders of Sebastopol had no help that they could reckon on. It has been seen that it was absolutely impossible for them to repel the enemy with only the force the garrison consisted of. So there remained to them no alternative but that of seeking to die gloriously at the post committed to their bravery."

A solemn ceremony of the Russian Church was ordered to be held

along the lines of defence. At an early hour the troops stood ranged in order of battle. Then the priests with images, gonfalons, and crosses, walked in procession along the lines, and performed divine service at each of the bastions, and the troops were sprinkled with holy water. "Let the troops first be reminded of the Word of God," said Korniloff, "and then I will impart to them the word of the Czar."

When the religious ceremony was ended Korniloff made a spirited address to the troops. He said, "The Czar hopes that we shall not give up Sebastopol. Besides we have nowhere to retreat to. We have the sea behind, the enemy in front. Prince Mentschikoff has deceived our enemies and got round them, and when they attack us our army will fall upon their rear. Remember then—believe in no retreat. Let the bands forget to play the retreat! Let him be a traitor who sounds the retreat! And if I myself give the order for retreating, kill me with the bayonet!"

In his addresses to the men of the land service, he added words to this effect: "Your business will be at first to receive the enemy with a well-directed fire of musketry; and if they should try to mount the batteries, receive them in the Russian style. You well know the work—at the point of the bayonet!"

Korniloff's address was received with the sound of bursting "Hurrahs!" which followed him through the lines.

In a work of this kind, it was necessary to give a somewhat lengthy description, although in a condensed form, of the defenders of Sebastopol up to the 28th September, 1854, and to show that the whole bearing of the conduct of the future defence of the place depended upon the resolution and energy of men such as Admiral Korniloff and Colonel de Todleben.

The Siege proper may now be considered to have been entered upon and the details of the operations will be related as far as is possible in the condensed form required by a work of this kind.

Governed as de Todleben was by his conception of two conditions, stress of time on the one hand, and on the other, the command that he had of all the ships' guns and munitions—he went on to frame his plan for strengthening the lines of defence, and with that view resolved "to choose a position as little extended and as near to the town as the nature of the ground would allow, and to arm its principal points with a formidable artillery; to connect these points one with the other by trenches to be defended by musketry; to establish there separate batteries, each armed with some pieces of cannon, and in this way to concentrate upon all the approaches of the town a powerful front and flank fire of artillery and musketry, endeavouring to sweep with as much fire as possible all the bendings of the broken ground by which the enemy might approach."*

* *Todleben*, Vol. I., p. 259.

The object of the works to be undertaken on this general plan was to provide against the event of an assault at whatever part of the line it might be attempted; but the way in which they were to produce their result was to be by enabling the garrison to meet every column of assault with a slaughtering fire.

de Todleben was always steadfast in declaring that against an assault of the Allies the garrison had but one defence. This lay in the volume of shot which the garrison might be able to pour into bodies of troops coming on within grapeshot range; and one single word, he used to say at the time, was enough to describe his main purpose—"Mitrail!"

The round shot, the shell, the bayonet, and the rifleman's far-ranging bullet had each, he acknowledged, its use; and now too if ever in war, the spade and the pickaxe were needed; but still in his mind, these things were chiefly of worth, because they either tended to avert the assault, or else, were more or less auxiliary and conducing to his one cherished purpose of meeting the assaulting column whatever the time, whatever the point of attack, with a pelting blast of mitrail.

There was also open to the defenders of Sebastopol, another and a more hopeful view of the future. The very sight of preparations for resistance might not only bring the enemy to adopt countermeasures for neutralizing these same preparations, but might even perhaps incline him to delay his attack. It was in fact hoped that the enemy might be induced to refrain from attacking Sebastopol, with a view to besiege it instead. The problem as stated by one who toiled at Korniloff's side* was to maintain a line of 4 miles against powerful armies with only a small body of sailors and militiamen; whilst the way to attempt its solution was by making the defences so formidable as to induce the enemy to forsake the idea of an immediate assault, and proceed to a regular siege.

Besides the task of connecting the still isolated works by intermediate entrenchments, it was necessary to deepen the ditches, to thicken and raise the parapets, to erect traverses, and to strengthen the ground by a great number of new batteries. Also, if only the enemy would give time enough, the armament along the whole line of defence was to be changed, and the lighter artillery replaced by heavy guns brought from the ships. Colonel de Todleben determined that the works should go on simultaneously along all the weak parts of the line; and each day's toil was to be so adjusted that it would not only effect a due approach towards the perfecting, after a time, of the work which had to be executed, but would also bring the impending improvements to such a state every night, that in event of an attack next morning they would still subserve

* Gendre, *Matérieux pour servir*, Chapter III.

the defence; so that if the enemy should grant a long respite, or if on the other hand he should assail in three days, or in two, or on the very morrow, the works—whether grown to full strength, or assailed whilst yet frail and weak—might in each case do all the good which the limit of time might allow.

And now by the ardour of Korniloff and de Todleben, all things and all people within the place were turned to the business of the defences. There was no ceasing. The people worked by relays. From dawn to sunset, between 5,000 and 6,000 men were busy along the lines of defence. By help of torches, other men, in less numbers, carried on the work through the night.

Colonel de Todleben, it would seem, was instinctively conscious that the power he was wielding depended very much upon his actual presence. He never wrote. He did not even read the communications which poured in upon him; for believing that he saw his way clear without the help of others, and being accustomed as an engineer to let his thoughts take the form of estimates and reckonings, he made as it were a computation, by which he assured himself that the probability of there being important matters in the papers before him, was not great enough to compensate the distraction and expenditure of most precious time which must be occasioned by reading them. It was with his own eyes, with his own voice, that he defended Sebastopol. At a later period when the besiegers could rest their field glasses on the gabions which covered their batteries they grew to be familiar with the aspect of an officer on a black charger, who was constantly seen in the Russian lines of defence; and they more than once pointed their guns with design to extinguish that untiring activity of one man, which (even from across the space which divided the besiegers and besieged) they could perceive to be of value to the garrison. In that ceaselessly diligent horseman, they saw the great volunteer whose brain was defending Sebastopol.

When the morning of the 28th had dawned, it still appeared that the Allies were undertaking no instant attack, but they were afterwards seen reconnoitring the defences of Sebastopol.

On the same day the deserted garrison of Sebastopol got tidings at last from Prince Mentschikoff's Army, and the officers who brought the message also brought news that the Prince had been reinforced by the arrival of 10,000 men under Khoumatoff, and was hourly expecting from the north fresh accessions of strength.

The next day, the 29th, the Allies were seen to be again reconnoitring, but again refraining from an attack, and the people of Sebastopol as well as the garrison were beginning to draw encouragement from the immense improvement that had been effected in the defences by several thousands of men always working by day and by night.

It was at the Malakoff, and the ground which flanked it on either

side that the greatest wonders had been wrought. Admiral Istomin, who commanded there, knew that the post was vital; but also he had been frankly told by Korniloff that it was weak. He had toiled with a ceaseless care, looking closely into all details, and guiding the labours of the multitude which had swarmed night and day round the work.

That simple white tower, the Malakoff, now famous in history, had been so changed in shape by the industry of the last three days, that it now closed high up round the centre of the building, and had not only begun to take the form of a glacis annexed to the original work, but was also the site of a new semi-circular battery which covered the front of the tower. This last battery was connected by entrenchments with the other new works thrown up on both flanks of the Malakoff. Ships of war were so placed in the creeks that their fire could search the ravines which descended into Sebastopol. To ease the passage between the town and the Karabel Suburb, a floating bridge was constructed, nothing was forgotten, nothing neglected, and on the night of the 29th September, the great engineer who had yearned to be in readiness with his pitiless storm of mitrail, might almost lie down to his rest with the contentment of one who had made his purpose sure.

When morning broke on the 30th September, it showed that the Allies were still abstaining from any attack. This was the sixth of the days which had passed since Prince Mentschikoff's Army had been withdrawn from Sebastopol.

In the course of the day the advanced guard of the Russian Army, commanded by General Jabrokritzky, appeared on the North Side; and the sight of his troopers was most welcome to the garrison and inhabitants of Sebastopol, as they imagined that the field army was returning at last to share in the perils and glory of striving to defend the place. But this joy at the time was ill-founded; for although some of Mentschikoff's troops had thus come once more within sight of Sebastopol, and could freely communicate with the town by crossing the ferry, their presence on the north of the roadstead was still far from really meaning that Prince Mentschikoff had resumed active warfare. Unless these newly-seen troops should be suffered to cross the water—and the prospect of such a movement seemed to be shut out by the order for transferring the army's heavy baggage from the South to the North Side—there would still be long difficult marches to divide them from the enemy.

In the course of the day, Prince Mentschikoff came down in person from the Upper Belbec to the Severnaya, but did not pass over the water. He rested in the Severnaya and there received the devoted Admiral who, since the two men last saw each other, had been forced by his love of country to usurp the command of Sebastopol.

Prince Mentschikoff gave assent to the kind of dictatorship which

had been created in his absence; for he treated it as quite natural that Korniloff had been raised to the supreme authority.

After complaining of the weakness of his army, and declaring his belief that the enemy was in great strength, he intimated that he was about to make another movement, and gave Korniloff to understand that he, the Prince, meant to leave Sebastopol to its own resources.

Korniloff remonstrated, and said: "If that takes place then farewell to Sebastopol! If the Allies decide on some daring action, they will crush us." Prince Mentschikoff then said that he would summon a council of war.

From the first the Russian Army in the Crimea had been scantily provided with skilled officers in the higher grades; and on the day of the Alma out of the number who were competent a large proportion was killed or disabled, and of the officers of rank who escaped some, at least, were in a great measure shorn of their due authority by the comments and the blame and recriminations which too often follow defeat. As a result for the time at least the army was much out of gear, and it seems probable that the weakness of his army in point of officers was so fully realized by the Prince afterwards that he thought it necessary to withhold his army for a time from the sight of the enemy's outposts.

(*To be continued*).

TIMBER TRESTLES AND RAILWAY BRIDGES.

By CAPT. P. O. G. USBORNE, R.E.

This subject is treated entirely from an active service point of view, only such materials as would probably be available being considered.

Road bridges for troops and vehicles, although identical in general principles, will not be touched upon here; they are fully described in *M.E.*, Part III.

Governing Factors.—(1) Rapidity of construction. (2) Material available. (3) Uncertain quality of materials and workmanship.

A Trestle Bridge consists generally of vertical timber frames suitably spaced out across the gap to be bridged, and spanned on top by "road bearers," or "stringers." These carry the sleepers and permanent way.

PRACTICAL POINTS.

Sleepers should be arranged close together over the span in order to distribute the weight of engine wheels, say 12 in. to 24 in. apart, centre to centre, or in pairs close together (*Fig.* 6).

Further distribution is sometimes obtained by using two layers of sleepers with a rail in between them, as in *Fig.* 10.

Stringers and Road Bearers usually consist of timber baulks, rails, rolled steel beams, or trussed timber beams. Any number of stringers are allowable.

Timber Baulks.—Four are usually employed, two under each rail. Where possible the length should equal twice the spacing of trestles, and adjacent stringers should be arranged so as to have their joints on alternate trestles.

If a single stringer is used under each rail, use a bolster to get good bearing (*Fig.* 4) or, better, overlap the ends of the stringers and bolt them together (*Fig.* 11). As the stringers are crossed by sleepers, it does not matter if they are not immediately below the rails.

Stringers should be given a shallow check (1 in.) over the top of a trestle, and should be spiked, drift bolted, or dogged to the cap. Sleepers are fastened to the baulks by spikes. Timber baulks are suitable for spans up to 15 ft. or 20 ft. Four 12-in. × 12-in. baulks, two under each rail are good for a 15-ft. span for all locomotives.

Rails.—Specially suitable as stringers for short spans, one or more together, laid side by side. Take care that rails are kept close together. This is done by spikes into the cap of trestle. Sleepers are held down by clip bolts (*Fig.* 5). Ends of rails should be embedded if possible on both sides of the gap, in order to make them fixed instead of supported, giving additional strength.

Five rails (steel, 56 lbs. per yard) under each rail are good for an 8-ft. culvert for all engines.

Fig 4

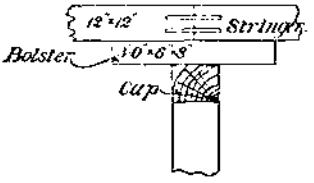


Fig 5.

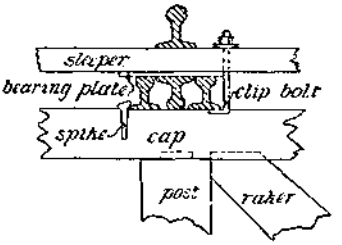


Fig 6.

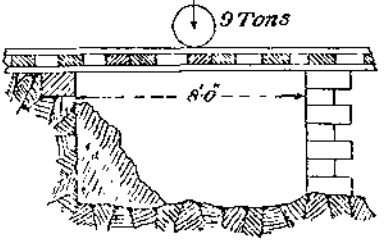


Fig 7.

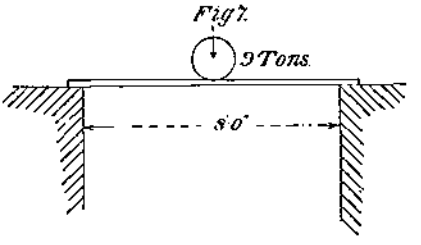


Fig 8.

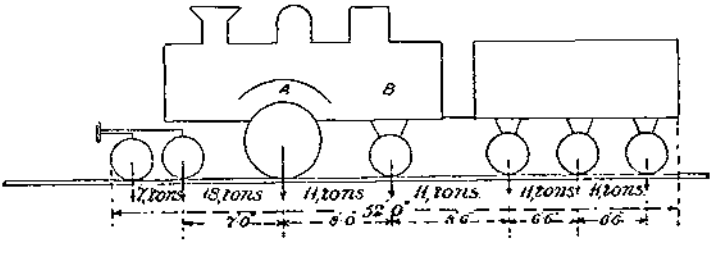


Fig 9.

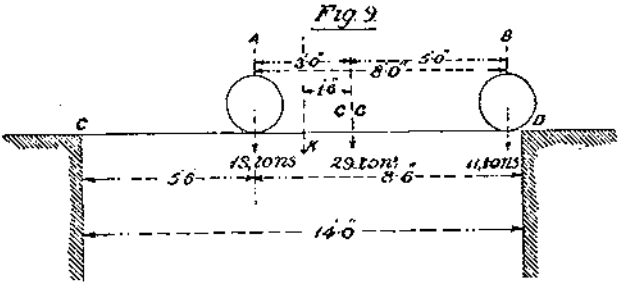
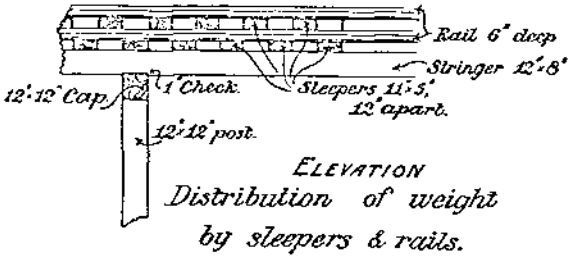


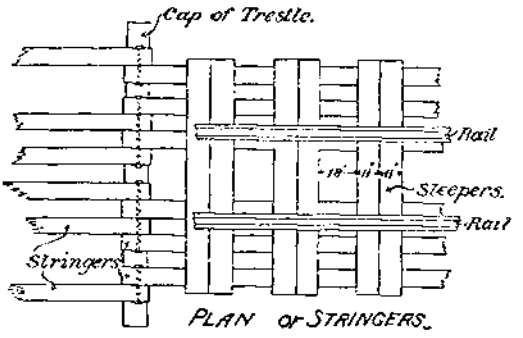
Fig. 10.



ELEVATION

Distribution of weight by sleepers & rails.

Fig. 11.



Meeting on a Trestle

CALCULATIONS FOR STRINGERS. THREE METHODS.

(i.). For small spans, 4 ft. to 10 ft., take the heaviest pair of engine wheels; assume them acting at centre of span, add a percentage for live load, shown in Table III., and work out as in Method I.

(ii.). For bigger spans, 10 ft. to 15 ft., where two or more pairs of wheels are on the span at one time, assume the two heaviest axles of engine to be on the span, add a percentage from Table III., and work out as in Method II.

NOTE.—When the distance between these two axles is greater than ·50 of the span, a greater M_f will be produced by the heavier axle at the centre of the span (as in case i.) than by the two axles in any position on the span together.

(iii.). For spans of 15 ft. and over, use the equivalent dead load given in Table IV. Add a percentage from Table III., and solve as a uniformly distributed load, as in Method III.

GENERAL FORMULÆ AND NOTATION.

The *Bending Moment* on stringers is :—

$M_f = \frac{Wl}{4}$ for a concentrated central load.

$M_f = \frac{Wl}{8}$ for a uniformly distributed load.

where W = total load on the span in lbs. or tons,

l = length of span in inches,

M_f = bending moment produced either in inch-lbs. or inch-tons, according to the unit of W.

The *Moment of Resistance* of a timber baulk is :—

$M_r = \frac{1}{6} rbd^2$ for rectangular section (timber),

$= \cdot 785\, r\, R^3$ for solid circular section (timber),

$= \frac{rI}{y}$ for all sections.

Where r=safe resistance per square inch to tension or compression in lbs. or tons.

b=breadth of beam in inches.

d=depth of beam in inches.

R=radius of the section in inches.

I=moment of inertia of the section in inch units.

y=distance of neutral axis to the extreme fibre, or half the depth of the section in symmetrical sections.

M_r=moment of resistance in inch-pounds or inch-tons, according to the unit of r.

In equating M_r and M_f, care should be taken that they are in the same units, either inch-pounds or inch-tons.

r, the safe intensity of stress per square inch, is usually taken as 1,200 lbs. in fir, 6½ tons in steel, and 5 tons in W.I. This is for permanent construction, and allows a factor of safety of 5 for timber, and 4 for steel and iron. For temporary work these values are low, and a factor of safety of 3 gives values of r:—

r=2,000 lbs. for fir.
r=9 tons for steel.
r=7 tons for W.I.

FACTORS OF SAFETY GENERALLY.

Stringers worked out by the formulæ and methods given in pp. 365 and 366 have much larger scantlings than those used in actual practice. The reason is that there are several factors of safety included in the formulæ:—

(i.). An addition is made from Table III. to compensate for live load, reducing it to equivalent dead load. For temporary work on service, the speed of trains over bridges can often be reduced; if this is possible, and the train crosses "dead slow," there is no necessity for this live load compensation whatever. If, however, it would interfere with expeditious running of trains to slow up, then the addition must be made.

(ii.). In railway work, the timber available will generally be well seasoned and sound (although the ends may be damaged). In this case, r may certainly be taken as 2,000 lbs. per square in. for fir, and all other timbers in proportion, based on a factor of safety of 3. If doubt exists, 1,500 lbs. may be taken, giving a factor of safety of 4.

If, however, the timber is new and unproved, a factor of 5 should be used.

On service, it will usually fall out that only one scantling of timber baulks is available; in such a case the Engineer must satisfy himself by inspection as to what factor to allow. If the factor of safety be reduced to 2 the material approaches dangerously near to its elastic limit; this cannot be allowed.

(iii.). In many cases stringers are really fixed or partly fixed at one or both ends, as, for instance, a stringer that is continuous over two spans.

(iv.). The distribution of the weight of an engine wheel by the rail and sleepers tends to reduce the bending moment of the stringer, making the concentrated load approximate to a distributed load. This is too indeterminate to allow for in calculating, but should be borne in mind.

NOTE.—Instead of adding a percentage for live load from Table III., r may be reduced as follows:—

Baltic fir	.. .. ..	r=20% reduction.
Steel	.. .. ..	$r=4\frac{1}{2}$ tons up to 20-ft. span.
		5 ,, ,, 30-ft. ,,
		$5\frac{1}{2}$,, ,, 80-ft. ,,

Deduct 20% from above values for steel for W.I.

At the same time, the use of Table III. is recommended, the practice of reducing r being rather arbitrary and uncertain.

The equivalent distributed live loads shown on Table IV. do not include any F. of S.

The discrepancy between theory and practice over small spans is not so much as for large spans.

The weight of superstructure is negligible throughout.

Table I. gives scantlings of timber commonly used in practice over various spans.

Table II. gives the safe loads on steel rails under all ordinary locomotives, over different spans, as used in practice.

Method I.—To calculate number of rails for road-bearers over 8-ft. gap (*Fig.* 6). *56-lb. steel rails* (*details, p.* 206, "*M.P.B.*").

This is a small span, so treat W as central load.

Heaviest axle load of engine=18 tons=9 tons per single wheel (*Fig.* 8).

Adding percentage from Table III., equivalent dead load=9 tons +27%=11·5 tons nearly.

(*a*). Consider the rails as supported beams. Then let n=number of rails required under each wheel.

$$M_f = M_r \times n.$$

$$\therefore \frac{Wl}{4} = r\frac{I}{y} \times n.$$

$$\therefore \frac{11{\cdot}5 \times 8 \times 12}{4} = 6{\cdot}5 \times \frac{I}{y} \times n.$$

To find I for the rail :—

Find the neutral axis by drawing out the section of the rail and dividing it up into rectangles.

Find their *c.g.* $Ay_0 = \Sigma A_1 y_1$ (y_0=distance of *c.g.* from extreme fibre).

Then find I by Appendix XIV., *Rivington*, Pt. IV., or *S.D.I.*, p. 100.

In this case, with a 56-lb. steel rail,

$y_0 = 2{\cdot}1''$.

$I = 12{\cdot}3''$.

Therefore, substituting—

$$n = \frac{11{\cdot}5}{4} \times 8 \times 12 \times \frac{2{\cdot}1}{12{\cdot}3} \times \frac{1}{6{\cdot}5}$$

$$= 7{\cdot}25.$$

Hence 8 rails are required under each wheel, giving the safe load on each rail as $11{\cdot}5 \div 8$, or 1·44 tons.

Compare Table II., which gives the safe load as 2·65 tons distributed, or 1·32 tons concentrated, and note that the normal value has been taken for r in this example, viz. : 6·5 tons.

(*b*). A formula is given for W.I. rails in the *R.E. Field Service Pocket Book*, p. 14.

$$S = \frac{\cdot 02\,(wgt)^2}{L}$$ where $\begin{cases} S = \text{safe load in tons for W.I.} \\ L = \text{length in feet.} \\ wgt = \text{weight per yard of rail in lbs.} \end{cases}$

for central load.

Substituting—

$$S = \frac{\cdot 02\,(56)^2}{8} \times \frac{6{\cdot}5}{5}$$ (ratio of steel to W.I. = 6·5 : 5) = 1·36 tons.

Since therefore 9 tons is weight on one wheel,

$$\text{No. of rails required} = \frac{9}{1{\cdot}36} = 7 \text{ nearly under each rail.}$$

Compare previous result. No percentage for live load is added here, the formula containing its own live load correction.

NOTE.—This formula is not recommended for general use, containing, as it does, special symbols and having no particular advantage over the ordinary $M_r = M_r$. It is merely quoted here for sake of collateral comparison.

(*c*). If whole rails, 30 ft. long, were employed, with their ends well and thoroughly bedded under the track on both sides of the gap that is to be bridged (*Fig.* 7), and the sleepers arranged close together on top, so as to get good distribution of load, the rails might safely be considered as "*fixed*" or "*half-fixed.*"

Consider the rails as "*fixed.*"

The M_f due to a central load on a fixed beam is $\frac{Wl}{8} = r\frac{I}{y}n$ as before.

Adding a percentage for live load and substituting—

$$\frac{11{\cdot}5 \times 8 \times 12}{8} = 6{\cdot}5 \times \frac{12{\cdot}3}{2{\cdot}1} \times n.$$

$$\therefore\ n = \frac{11{\cdot}5 \times 8 \times 12}{8} \times \frac{2{\cdot}1}{6{\cdot}5 \times 12{\cdot}3}$$

$$= 3{\cdot}62.$$

Therefore four rails are required, *i.e.*, half the number found above in (*a*).

(*d*). If work were hurried, and fixing appeared to the Engineer to be dubious, "*half-fixed*" might be allowed for, giving six rails as the necessary minimum under each wheel.

Method II.—Take a 14-ft. span, timber baulks, and 78-ton Midland engine; calculate baulks (*Figs.* 8 and 9).

Consider the two heaviest axles, 18 tons and 11 tons, called A and B in *Fig.* 9.

First find the *c.g.* of A and B. Let *c.g.* be x ft. from A.

Taking moments round A—

$$(18 + 11)\,x = 11 \times 8,$$

$$x = \tfrac{88}{29}$$

$$= 3' \text{ nearly.}$$

The rule for two rolling loads on a span, when kept at a fixed distance apart, is this :—

"*The maximum* M_f *occurs under the heavier load, at the moment when the centre line of the span bisects the distance between the heavier load and the c.g. of the two loads.*"

Draw the two heaviest axles in this position, as in *Fig.* 9, so that A (18 tons) is 1 ft. 6 in. from the centre of span. This is the position of maximum M_f.

To obtain R_c (reaction at C), take moments round D.

$$R_c \times 14 = 18 \times 8'\ 6'' + 11 \times 6''$$

$$= 18 \times 8\tfrac{1}{2} + 11 \times \tfrac{1}{2}.$$

$$\therefore\ R_c = 11{\cdot}32 \text{ tons.}$$

Now, the bending moment at A

$$= R_c \times 5'\ 6''$$

$$= 11{\cdot}32 \times 5\tfrac{1}{2}' \text{ tons.}$$

$$= 62{\cdot}26' \text{ tons.}$$

Adding 23% from Table III., $M_f = 76'$ tons.

Substituting in the formula :—

$$M_f = \tfrac{1}{6} r b d^2.$$

$$76 \text{ (ft.-tons)} \times 12 \times 2{,}240 = \tfrac{1}{6} \times 2{,}000 \times bd^2.$$

$$\therefore \quad bd^2 = \frac{76 \times 12 \times 2.240 \times 6}{2{,}000}$$

$$= 6{,}120 \text{ nearly.}$$

This is for the whole track, axle load having been taken.
Assume four stringers, two under each rail.

$$\text{Then } bd^2 \text{ for each} = \frac{6{,}120}{4}$$

$$= 1{,}530$$

$$= 10 \times 12^2 \text{ nearly,}$$

$$\text{or} = 9 \times 14^2.$$

Hence two 12 in. × 12 in. under each rail will be ample, or two 9 in. × 14 in., or even one 14 in. × 14 in.

Compare this result with Table I., and note the large value taken for r above. If r had been taken as 1,500 lbs., two 10 in. × 14 in. baulks would have been required.

NOTE.—If the span in the preceding example had only been 13 ft., the distance between the heaviest axles would have exceeded ·59 of the span, and the greatest M_f would have been produced by placing the 18-ton axle at the centre.

Method III.—Calculate stringers for a 20-ft. span ; 78-ton engine.

From Table IV. the uniform equivalent load for this span is about 3 tons per foot-run.

$$\therefore \text{ total load} = 3 \times 20 \text{ tons}$$

$$= 60 \text{ tons.}$$

Formula then is :—

$$\frac{Wl}{8} = \tfrac{1}{6} r b d^2.$$

$$\therefore \quad bd^2 = \frac{60 \times 20 \times 12}{8} \times 2{,}240 \times \frac{6}{2{,}000}$$

$$= 12{,}096.$$

This is for the whole track, axle loads having been taken.
Assuming two stringers under each rail,

$$bd^2 \text{ for each} = 3{,}024$$

$$\text{if } b = 9''.$$

$$d^2 = 336.$$

$$\therefore \quad d = 18'' \text{ nearly.}$$

Therefore two 9 in. × 18 in. under each wheel will do.
Compare Table I., and note value of r taken.

Summary of Calculations.

"*Temporary*" and "*Semi-permanent*" work must be distinguished. The former implies work executed hastily, and not intended for use for more than a few weeks at the most; the latter implies some considerable duration, up to six months or a year, or even the whole of a campaign.

Temporary work, therefore, admits of the use of large constants, such as 2,000 lbs. for a value of r in timber, small factors of safety, and possible omission of all percentage for live load, if trains can be sent over the bridge "dead slow."

Semi-permanent work on the other hand calls for more care and a larger factor of safety, and the percentage for live load should always be added.

In both cases the permanent way must be most carefully laid and maintained, and the sleepers must be close together, each supplying a firm bearing to the rail above.

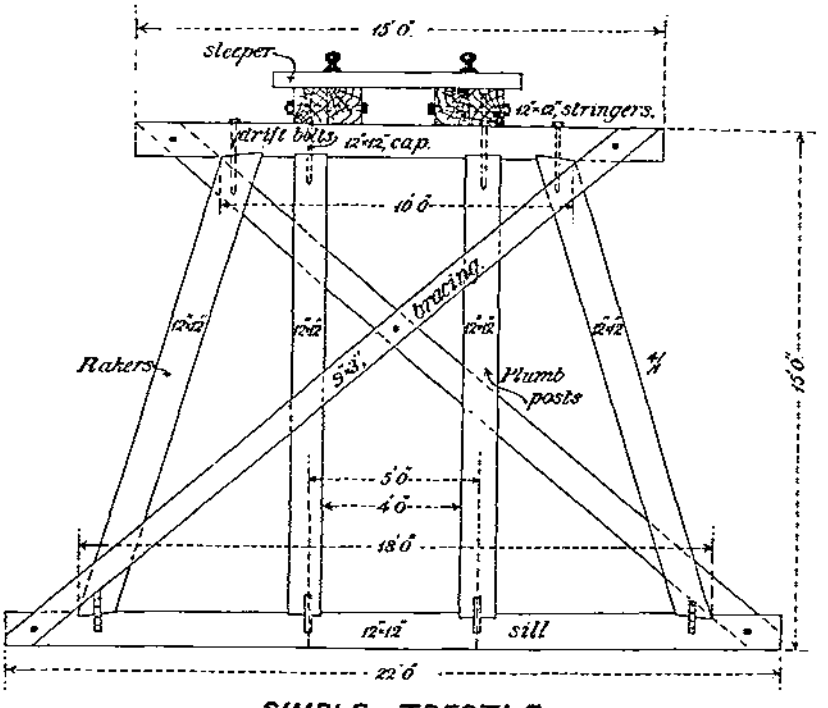
Trestles.

Trestles are treated under the following heads:—

Framed trestles, pile trestles, high framed trestles, trestle piers, crib piers, other piers.

Framed Trestles (*Fig.* 1).—A framed trestle generally consists of

Fig. 1.



SIMPLE TRESTLE.

two upright posts placed underneath the rails, called "*plumb posts*," and two outer sloping posts called "*rakers*."

These rest on a "*sill*" at their lower ends, to distribute their weight on the foundations, and they are covered by a "cap" at the upper ends, to carry the stringers. The posts, sill and cap are fastened together either by "*fish-plates and bolts*" or by "*dogs*," or by "*drift bolts*." Drift bolts are long iron spikes with a point one end and a head at the other.

Trestles are sometimes braced together by *sway bracing*, as shown in *Fig.* 1; and in order to keep them in a vertical position, *longitudinal bracing* is sometimes required from the top of one trestle to the bottom of the next, along the direction of the bridge.

Framed trestles are used in one panel up to 20 ft. high, or sometimes 30 ft.

Over 20 ft. high usually make in two panels. Convenient spacing 15 ft. Posts 12 in.×12 in., or 10 in.×12 in., cap 12 in.×12 in. Sway bracing 9 in.×3 in., or 12 in.×3 in., bolted. Cap, drift, bolted, or dogged, spiked, etc., bottom sill 12 in.×12 in., notched for posts usually.

Plumb posts should be under rails; head of rakers 1 ft. to 1½ ft. clear to either side, feet 3 ft. 6 in. to 4 ft. 6 in. clear to either side.

Up to 6 ft. high four vertical posts are good; above 6 ft. use rakers.

Level up after fixing the stringers, by wedges under trestles. Base should be anchored against rush of water, etc.

To test the posts for stiffness (not usually necessary), assume 16-ft. span, 2½ tons per F.R. Then total weight=40 tons: if bd=section of a post, $4bd$=total cross section of posts of trestle.

$$\therefore\ 4bdr_c = 40 \text{ tons.}$$

$$\therefore\ bd = \frac{40 \times 2{,}240}{1{,}000 \times 4} = 22{\cdot}4.$$

$$\therefore\ b = 4,\ d = 6.$$

∴ 10″×12″ posts are ample.

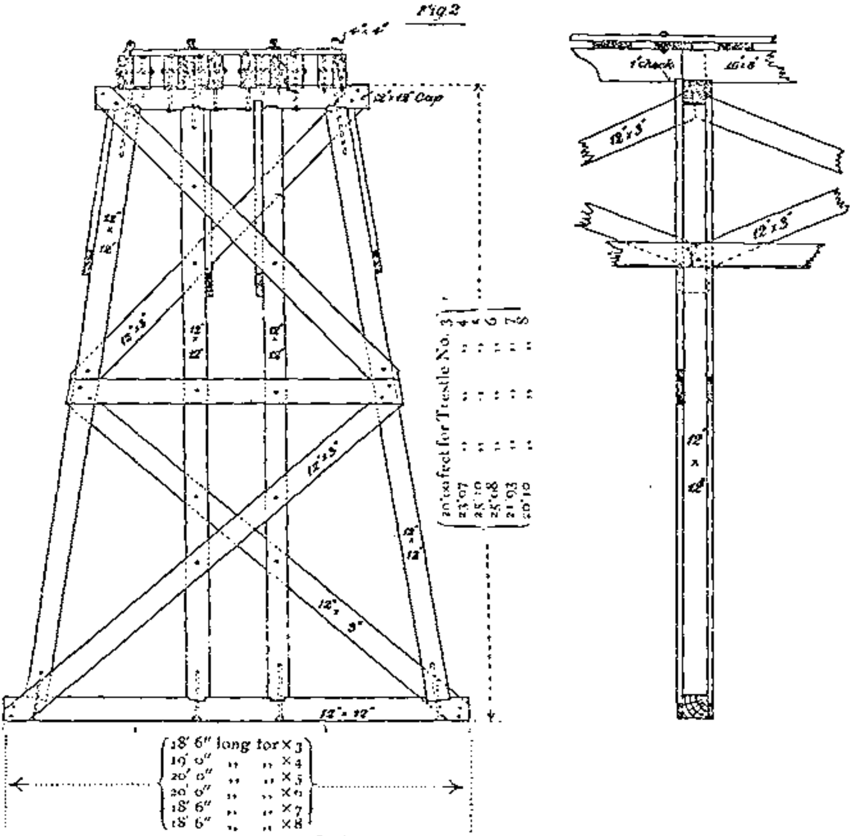
Pile Trestles.—Not in frequent use; too slow for hasty work; useful on soft foundations. Four piles driven into ground; all vertical up to 10 ft. high—above 10 ft. outside two driven raking (slope $\frac{1}{4}$); usually 12 in.×12 in.; cut off to level and capped with 12 in.×12 in.; drift bolted; sometimes morticed and tenoned, usually notched. The posts should be spaced as in framed trestles.

Sway bracing required (3 in.×9 in. or 3 in.×12 in.) when trestle is more than 10 ft. high.

High Trestles.—Make in two panels; upper panel of even length, say 15 ft. high throughout the bridge, odd length in bottom panel, to suit the conformation of the bottom. Members of upper trestle in prolongation of lower.

Horizontal bracing is carried all along at each tier. Diagonal

longitudinal bracing may be provided to every bay; or every third bay may be braced into a tower, if necessary, to keep lots of waterway clear in adjoining bays.



HIGH TRESTLE.

Trestle Piers.—Where very high trestles in use, put in pairs close together; to form piers or towers, cross-brace firmly all the way up.

For span 40 ft. place them 5 ft. apart.
For span 20 ft. place them 4 ft. apart.
For span 10 ft. place them 3 ft. 6 in. apart.

Trestle piers should always be used when the span between high trestles exceeds 25 ft.

Crib Piers consist of sleepers piled cross-wise on top of each other. They are very wasteful of sleepers; quickly erected; require no skilled labour; large working parties can work on them—but they block up waterway—must be filled and surrounded with stones or concrete when required to resist flow of water. They are notched together, or merely spiked. For erection in water, construct bottom part on shore; floor in bottom; float off and then sink by filling with stones.

Up to 8 ft. high use single crib piers.

From 8 ft. to 18 ft. use double crib piers, transversely to the permanent way.

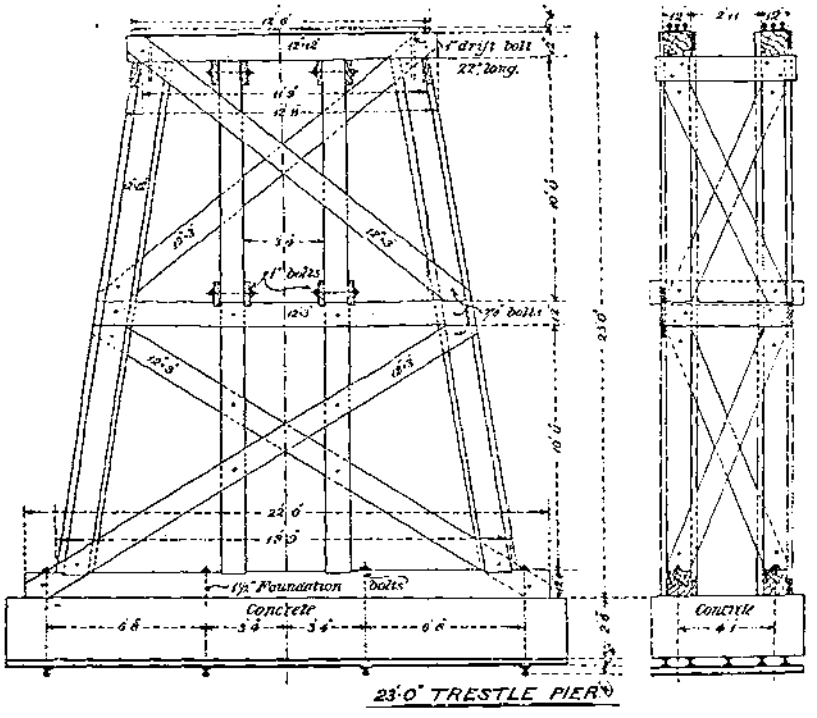
Over 18 ft. use treble crib piers.

These must be tied through longwise with rails at intervals.

Above 18 ft. high speed of erection and economy decrease very rapidly.

Maximum economical height=25 ft.

Fig. 3.



23'-0" TRESTLE PIER

Sandbag, Stone, Concrete Piers, etc.—Stones or sandbags can be used as revetments to low earth piers, when clear of water. Stones or sandbags can be used alone, as temporary expedient. When using earth pier with sandbag revetment, top of pier should be—

12 ft. × 6 ft. for 40-ft. span
12 ft. × 5 ft. for 20-ft. span
12 ft. × 4 ft. 6 in. for 10-ft. span
} Batter of sides $\frac{1}{6}$.

On the top rests a solid wooden frame of 6-in. stuff to take superstructure or bearers.

A similar frame should be introduced into the pier every 5 ft. of height for bond.

Concrete is not much used in hasty work, but very much used for footings in semi-permanent work or low piers.

Joints.—All bolts $\frac{3}{4}$-in. diameter, with washer at head and nut.

$\frac{3}{4}$-in. to $1\frac{1}{4}$-in. bolts take 3-in. to $4\frac{1}{2}$-in. diameter washers $\frac{3}{4}$ in. thick.

Drift bolts are $\frac{3}{4}$-in. square or round iron.

Smooth rods are better than jagged in timber.

Round have 25% more holding power than square.

1-in. round bolt in $\frac{3}{4}$-in. hole in Norway pine has 9,000 lbs. pull per F.R.

All bolt holes $\frac{1}{8}$ in. smaller than bolt.

Screw bolts 50% more hold than smooth.

Spikes.—Straight, with chisel point are best (*M.P.B.*, p. 202).

Holding pull=300 lbs. per square inch of surface of spike in fir. Holes half diameter of spike.

Dogs.—$\frac{3}{4}$-in. iron. Their points should be sharpened by bevelling on the inside only, so as to draw together the parts that are being joined.

Foundations.

Rock.—Rest the sill of the trestle on a bed of rock cut level, or made up level with concrete. If below water, make up level with concrete in bags.

Ordinary Soil.—The sill is laid on a platform of sleepers cut in half, placed transversely to the sill. It must depend on the soil whether this platform need be continuous or is only required under the posts.

The sill must be anchored if below flood level or below water.

Sand.—Use a low crib pier resting on a floor of sleepers, or cover a large area with crossed sleepers several layers deep, if the sand is very soft, and found on this.

Bog, Sludge, Mud.—Use long spans between trestles. Under the trestles use piles, or cut a trench through the soft stuff on to the hard, and fill with solid filling, *e.g.*, concrete.

For piles a convenient arrangement is two rows of piles 5 ft. apart, and 5 ft. spacing.

Scouring.—In permanent work, the masonry of the bridge is joined up under water to form an apron, in small spans.

In temporary work, spans up to 10 ft., floor in the underneath with timber flooring and drop walls. Bigger spans, pile ground over with boulders 1 ft. deep or so, with a big pile round each trestle foot. Carry foundations well down; ordinary soil, masonry abutment:—

10-ft. span, 3 ft. deep
20-ft. span, 4 ft. deep } To prevent scouring.
40-ft. span, 6 ft. deep

Trestle piers should be protected by piled stones, or if current liable to become very strong, by crib piers filled with stones; or sheet piling, triangular in plan, like a dolphin. Concrete flooring is sometimes put in under the spans.

TABLE I.

TABLE OF SCANTLINGS FOR STRINGERS.

(The numbers given are for both rails, *i.e.*, half under each rail).

DEPTH OF BEAM IN INCHES.

Span. d=	20″		18″		17″		16″		15″		14″		13″		12″		11″		10″		9″		8″	
	No.	b	No.	b	No.	b	No.	b	No.	b	No.	b	No.	b	No.	b	No.	b	No.	b	No.	b	No.	b
25′	..	..	6	9″	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
22′	..	..	2	18″	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
20′	2	20″	4	9″	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
18′	..	..	4	9″	..	..	6	8″	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
16′	..	..	..	..	3	8″	4	8″	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
15′	..	..	2	9″	2	10″	1	8″	..	..	2	14″	..	..	4	12″	..	..	..	..	..	..	..	..
12½′	..	..	..	..	..	..	2	8″	..	..	4	6″	..	..	3	12″	..	..	..	..	..	..	..	..
10′	..	..	..	..	..	..	..	..	2	8″	..	..	..	..	3	12″		..	..	..	..	..	..	..
8′	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	12″	..	..	..	..	..	..	..	..
6′	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	12″	..	..	..	..	..	..	..	..

Equivalent of any of these easily found by multiplying up $b\,d^2$, and then altering value of b or d as required, or adding or deducting percentage for increased weight of engines, etc., etc.

These data are compiled from Railway Report, S.A. War and other engineering books, and are the result of practical experience, for ordinary semi-permanent work—for 68-ton engines or over, up to 100 tons.

They may be taken as good enough for hasty work in the field.

Timber baulks—good Baltic fir, where $r_c = 1{,}500$ safe.

TABLE II.

TABLE OF SAFE LOADS ON SINGLE RAILS IN TONS.

(NOTE.—Flanged steel rails of standard sections, *M.P.B.*, p. 206).

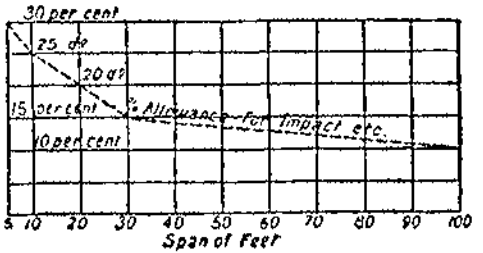
WEIGHT IN LBS. PER YARD RUN OF RAIL.

Span.	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
12′	·713	·90	1·09	1·31	1·53	1·77	2·02	2·27	2·51	2·75	2·98	3·21	3·44	3·69	3·91
10′	·856	1·07	1·32	1·57	1·84	2·12	2·42	2·73	3·01	3·29	3·57	3·85	4·13	4·43	4·69
8′	1·07	1·35	1·65	1·96	2·30	2·65	3·02	3·41	3·77	4·12	4·47	4·82	5·16	5·53	5·87
7′	1·22	1·54	1·89	2·24	2·63	3·03	3·46	3·90	4·31	4·70	5·10	5·51	5·9	6·33	6·70
6′	1·43	1·80	2·2	2·62	3·07	3·54	4·04	4·55	5·02	5·49	5·87	6·42	6·88	7·38	7·83
5′	1·71	2·16	2·63	3·14	3·68	4·25	4·84	5·46	6·03	6·73	7·14	7·71	8·28	8·86	9·39

The above are in tons for 1 rail, distributed load.

For central load divide by 2.
30% is allowed for live load; r_c for steel = 6·5 tons.
For small spans, over culverts, etc., up to 12 ft., load must be considered central.
Spans 12 ft. and up can be treated as distributed, equivalent distributed load being used from Table IV.

TABLE III.



From *The Engineer*, May 8th, 1903.

TABLE IV.

TABLE OF EQUIVALENT DISTRIBUTED LIVE LOADS FOR HEAVIEST LOCOMOTIVES IN GREAT BRITAIN ON SINGLE-LINE TRACK.

Span in feet	10′	15′	20′	25′	30′	35′	40′	45′	50′	60′	70′	80′
Tons per foot-run	3·99	3·72	3·44	3·35	3·28	3·06	2·88	2·67	2·50	2·27	2·27	2·26
Span in feet	90′	100′	120′	140′	160′	180′	200′					
Tons per foot-run	2·25	2·24	2·23	2·22	2·21	2·20	2·18					

From Paper by Mr. J. C. Inglis, M.I.C.E., in *Proceedings of Institute of Civil Engineers*, Vol. CLIV., p. 22.

TRANSCRIPT.

HISTORY OF UNDERGROUND WARFARE.

Being a Review of the book by A. GENEZ, Captain of Engineers, French Army.—(Librarie Militaire Berger Levrault, Paris, Rue Des Beaux-Arts 5-7, 1914. Price 5 francs).

(*Concluded*).

SIEGE OF TU-YEN-KWAN, *23rd November*, 1884, *to 3rd March*, 1885.

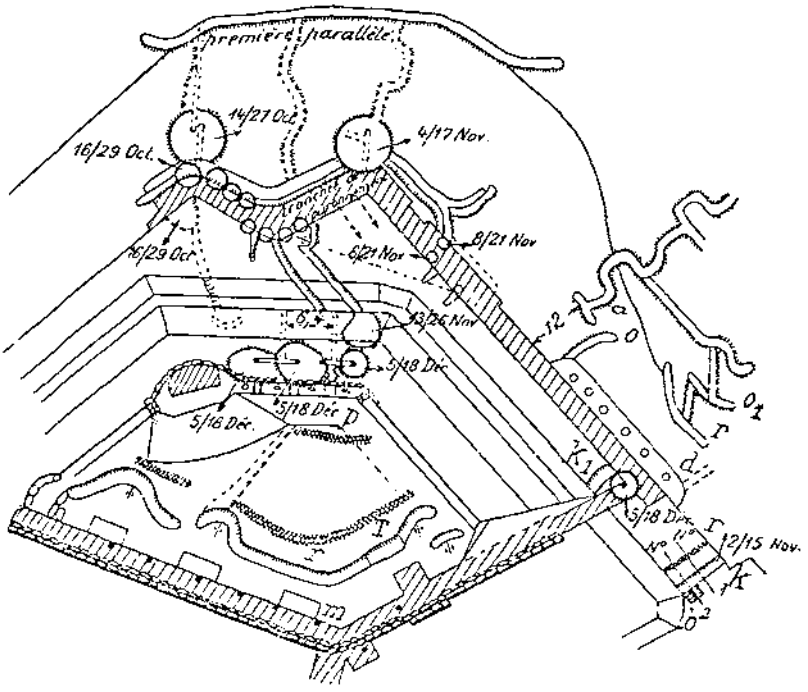
During the Tonkinese War 600 men held Tu-yen-kwan against a Chinese army. The latter fired 10,000 shells and 1,000,000 cartridges, opened 5 miles of trenches, excavated 10 galleries, and fired 7 mines. Improvements to the defences and countermine works were all directed by Serjt. Bobillot, of the Engineers, to whose zeal, intelligence and initiative the success of the defence was in a great measure due. The defenders had no powder for mines, all they could do was to try to penetrate the enemy's galleries, and if not successful in doing so, at any rate their countermine galleries might constitute a species of safety valves, and dissipate harmlessly to some extent the effect of the enemy's explosions. The little garrison held out long enough to enable a column to arrive to relieve them.

SIEGE OF PORT ARTHUR, *May*, 1904—*January*, 1905.

Omitting all general description of the country, fortifications, and strengths of the rival armies, the progress of the underground warfare only will be followed. The most important works were those undertaken against three of the detached forts, North Ki-kwan, East Erh-lung and Song-shu-shan. The Russians were driven within their main line of defence on the 28th of July, 1904. Between the 19th and 25th of August the Japanese Army, under General Nogi attempted an *attaque brusquée*, and gained a little ground, but it was evident that regular siege works would have to be undertaken.

North Ki-kwan Fort is pentagonal in shape, its front facing north-east. The parapets of the face and flanks were 10½ ft. above the terreplein and 24½ ft. thick. The ditches were not revetted, and were about 13½ ft. deep and 25 ft. wide. The flank ditches were enfiladed from casemates built opposite the front face in the counterscarp, which was indented for that purpose. The walls and roofs of these casemates were of concrete 3 ft. thick. Communication with the interior of the fort was by a counterscarp gallery sloping downwards along the right flank as far as the gorge, and then by a passage under the ditch. At the time of the siege these galleries were incomplete. Double-storeyed barracks with ditches closed the gorge faces, and the gorge ditch to the left was

flanked by a caponier. Sandbag parapets were erected on the barrack roof. There was a bridge over the gorge ditch which was under fire from the Japanese position.



Works of Attack and Defence of Fort No. II.

At each flank of the casemates in the salient two arches had been left, from which countermine galleries were to have been driven, but these had not been commenced. By the middle of September the Japanese saps were not far from the fort, and it appeared that further progress was being made by mining. On the 14th countermining was begun by parties of 16 men with 8-hour reliefs, the Sappers were untrained in mining, most of the picks and shovels had been lost in the advanced positions (Nan-shan, etc.) and those bought locally were of very inferior quality. Later on a few tools of extreme lightness and strength were captured from the Japanese, indeed they were the object of several sorties. In the left-hand gallery work proceeded rapidly, in the right-hand gallery rock had to be removed with hammer and chisel.

As nothing definite was known of the Japanese mines, a sortie was organized on the 15th of October. The troops were armed with rifles, hand grenades and torpedos of guncotton in tin cylinders, the last intended for blowing up the Japanese mine shafts. The sortie failed, and a similar attempt next day met with as little success, countermining proceeded therefore very much by guess work. On the 16th the left gallery was about 17 ft. long when the crater of a Japanese shell was broken into. As no plans of the fort were available, the gallery had been driven too close to

the surface of the glacis. The opening was closed and a shaft sunk a yard further back to 13-ft. depth, whence the gallery was continued towards the front. Part of the shaft was cased in, the remainder was not revetted. On the 17th accessory defences were prepared by fixing fraises on the berms, wire entanglements in the ditches, and fougasses, and planks studded with nails on the glacis. Every fougasse to be fired electrically was abortive, the conductors had been laid on the ground, and were all sooner or later cut by shells.

On the 20th of October a fairly successful sortie took place, and it was ascertained that the Japanese had two galleries, one directed towards the centre of the front face, and another towards the left salient. This was, as a matter of fact, wrong, there was only one gallery; it would appear that the reports of soldiers were relied upon, and that no officer had been specially detailed to verify the information. On the 23rd from the left gallery the Japanese miners were heard, on the 24th the Japanese stopped work when the Russians did so, and *vice versâ*. It was evident that each knew of the other's presence. On 25th two more shafts were sunk in the floor of the casemates, whence fresh galleries could be driven if required. On the 26th it was estimated that the Japanese were only 5 ft. away to the left of, and slightly above the Russians. Lieut.-Colonel Rachevski, of the Engineers, calculated at 210 lbs. the charge for what was intended to be a camouflet, with L.L.R. of 21 ft., and coefficient for loamy soil, but Colonel Grigorenko, the Chief Engineer, using the higher coefficient for rock, decided to use 285 lbs. There was no powder nor means of ignition in the fort, and an officer of the *fougassiers* was sent for to bring the necessary materials. At 8 p.m. the Governor, Lieut.-General Smirnov, arrived, gave orders to charge the mine, and expressed a wish to fire it himself. Five detonators were placed in the charge, the conductors were 5-stranded and lead sheathed, and were taken from the mine in two groups in case of accident. A man watched a galvanometer during the charging and tamping to make sure of the electrical continuity of the circuit. A man was placed in the gallery to work with a pick, and deceive the Japanese as to what was really going on. Air spaces seem to have been left in the tamping. The mine was fired at mid-day on the 27th of October, and two officers standing in the casemates close to the entrance to the gallery heard no noise at all. Mr. David James, an English correspondent with the Japanese, relates that a squad of six of the Engineers of the guard worked till the last endeavouring to reach the Russian mine and remove the powder. Three were afterwards taken out badly wounded, the other three must have been killed. The explosion destroyed a large portion of the Japanese gallery, at the same time the ground was so disintegrated that the latter were able next day quickly to drive a sap up to the concrete wall of the casemates. Another report states that a corner of the building was actually exposed at the rear edge of the crater.

On the 28th the Japanese blew a large hole in the corner of the casemate, the explosion extinguishing the lights in the rooms. Miners' candles were distributed and lighted, rifles posted to prevent the Japanese entry, and attempts were made to block the hole with sandbags. A sandbag parapet was erected in the next room opposite the communicating arch-

way. The Japanese now blew up the sandbags in the hole they had made, and leaping in, drove the Russians behind their parapet, and placed a machine gun opposite it. Hand grenades were thrown, and the air became so vitiated that the candles were again extinguished. A Russian grenade set fire to some explosives brought by the Japanese, partially wrecking the casemates, and driving the Russians back to the further rooms. Colonel Rachewski now arrived, order was restored, and the Japanese driven out. After some time an officer of the Russian Engineers and a soldier managed to slide into the ditch, and blew in a loophole of the casemate on the left of the Japanese sap, entered the room, and secured themselves with sandbags. Grenades thrown through the hole, and a hot fire from the ramparts, checked all further approaches of the Japanese, on the other hand neither could the Russians break out.

The Russians now placed explosives in the walls separating the rooms of the casemates in their rear, for use in case they were driven back. They were arranged to be fired electrically from the counterscarp gallery. Meanwhile their right gallery had advanced about 35 ft., and a charge of 575 lbs. powder was placed in it. On the night of the 30th of October the Japanese breached the roofs of the remaining three rooms of the left half of the block of casemates, and drove the Russians into the right half. The Russians were thus no longer able to enfilade the ditch of the left flank of the fort. A party of Japanese tried to escalade the escarp, but were driven back.

On the 31st Japanese assaulted the right half of the casemates; the countermine prepared in the right gallery was fired and they retired. At 7 and 9 p.m. general assaults were made and repulsed.

On the 2nd of November the Japanese drove a sap round the back of their half of the casemates, and, entering the ditch by holes made in the front wall, managed to secure themselves on the exterior slope of the front face. In order to make sure of hitting them in this position the Russians had to tie grenades to cords, or their missiles rolled harmlessly into the ditch. The Japanese made wire screens to catch them, and could not be dislodged, indeed they had commenced a mine gallery in the exterior slope. The Russians placed a *cheval de frise* in front of the site of the expected explosion.

By the 9th of November the Russians had been driven out of three of the five rooms in the right half of the casemates, and the Japanese had pushed a mine gallery along the outside towards the right. On the 10th the Russians fired a second countermine from their right gallery. The tamping was insufficient, and smoke and flames were forced back into the casemate, but the Japanese gallery seems to have been damaged. On the 14th a third countermine was fired, of guncotton this time, as there was so little space for tamping. Some Japanese must have been cut off in their trenches by this explosion; they presently sent five carrier pigeons out to convey news of their predicament.

The Japanese were still heard at work outside the casemates, and on the 17th a fourth mine was fired from the right-hand gallery. It was at first intended to fire 70 lbs. guncotton, but this charge was doubled in the hope of securing a greater effect. The result was disastrous for the Russians. The back wall of the casemates was shattered, and the

opening into the countermine gallery was exposed. The Japanese then attacked, but were driven off. A traverse was built opposite the opening, and a sort of fougasse was prepared and fired, but its only effect was to knock down the traverse. The latter could not be restored, and the Russians withdrew from the last casemate into the counterscarp gallery. The fight for the casemate had lasted six weeks, and for the next month a desperate struggle underground was to follow for possession of the gallery.

On the 19th of November the Japanese placed a 3-in. gun in the casemates, and destroyed the gorge caponier, but this gun was shortly put out of action by fire from the Little Eagle's Nest Battery. Three other guns consecutively met with the same fate. The Japanese then tried pumping an irrespirable gas into the counterscarp gallery, but this was remedied by making another opening, and operating a diver's pump to increase the ventilation.

On the 21st of November the Japanese boldly entered the ditch and blew in the wall of the counterscarp gallery behind the Russians, and fired through the opening with a 2-in. gun which they had brought into action in the ditch, behind the parapet of the covered way they had built leading to their gallery under the escarp of the front face. The Russians retired behind the next breastwork which they had erected, and a third breastwork was constructed further in rear. The Japanese also sapped along the back of the gallery wall, and blew another hole opposite that made from the ditch. The arched roof was blown in, and more asphyxiating gas pumped in, probably obtained by burning guncotton or melinite. The hole in the roof could not be closed for fear of suffocation.

The Japanese now made a traversed approach from the Kouropatkin Redoubt, which they had captured in September, towards the middle of the gallery, where the wall had not yet been covered with earth. They were within 50 ft. when the Russians began a counter-approach from the back of the wall. Fortunately a Russian sortie from the Kouropatkin Lunette succeeded in partly destroying the Japanese trenches.

Work on the gallery under the parapet had been pushed on actively, and on the afternoon of the 26th of November, after a tremendous cannonade from the siege batteries, the Japanese exploded two mines on the front face near the right salient, and assaulted the fort. A hand-to-hand fight ensued, and the Japanese were ultimately repulsed. At 1 p.m. Colonel Aoki himself rushed on to the parapet with the flag of his regiment, but the attack he led was also repulsed with great loss. The Japanese, however, held on to the mine craters and were only driven from them after nightfall. This was part of a general assault on all the works, in which the Japanese lost 12,000 men.

A calm followed, and the opportunity was seized by the Russians to construct a retrenchment in the fort, opposite the expected breach, and place in it two guns and two machine guns. The Japanese also recommenced their work on the exterior slope in spite of the grenades thrown by the garrison. They also repaired their sap opposite the right flank. While collecting their wounded the Russians took note of two Japanese mine galleries under the parapet on a level with the berm near

the right salient, and another near the left. The retrenchment was strengthened with wire entanglement.

On the 4th of December the Russians unsuccessfully attempted to demolish, during a sortie, the Japanese approach on the right flank. They placed automatic fougasses in the hollow behind the wall of the counterscarp gallery, which besides causing loss to the enemy, would serve to warn the Little Eagle's Nest Battery that the fort was being attacked. Shots were still being exchanged daily in the counterscarp gallery.

On the 9th of December the Russians began to drive a gallery from the counterscarp gallery towards the Japanese saps on that flank. By the 13th the hourly expectation of explosions under the front parapet had reduced the garrison to an indescribable state of nervous tension. To counteract this two Boules' shafts were sunk in the terreplein for countermines, and a listening gallery in the parapet was loaded as a mine. On the 15th the Japanese threw some lighted arsenical compound into the counterscarp gallery to smoke out the Russians. Some hours later General Kondratenko and Colonel Rachevski were killed in the fort by the bursting of a 28-c.m. shell. In the death of the latter the defence experienced a severe loss.

Up to the 17th of December there was great indecision about charging the Boules' shafts in the fort. Capt. Schwartz, of the Engineers, wished to charge them, his arguments being firstly, that a Russian explosion would cause no panic in the fort, and would forestall the enemy, and secondly, that if the latter overheard the Russians tamping they would promptly fire their mines, but the garrison would be prepared for such an event, and would not be caught unprepared. General Foch would give no decided answer, so von Schwartz referred to General Gorbatovski who consulted the Chief Engineer. A council was convened and it was decided to charge the shafts on the 18th. This was too late.

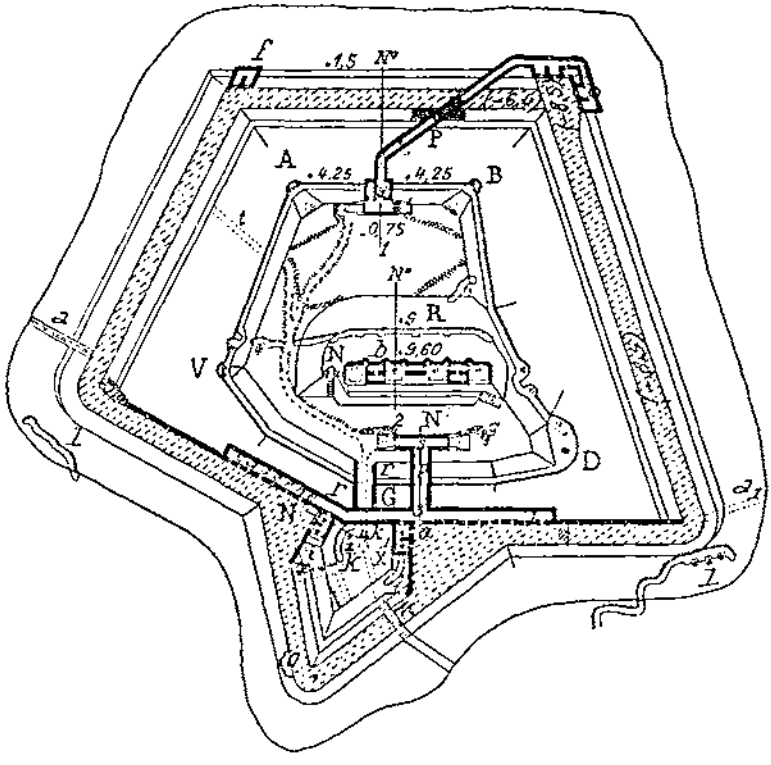
On the 18th at 10 a.m. the Japanese opened a heavy fire on the fort. At about 1.30 p.m. three successive explosions took place in the front face of the fort, and the intensity of the fire was increased. As soon as order was restored guns and machine guns were cleared of the earth which covered them. A Japanese assault after the first explosion had been repulsed, a second assault after the second explosion was overwhelmed by the third explosion, which appears to have been premature. At 3 p.m. Colonel Aoki's regiment held the forward edge of the craters. Only 20 Russians in the fort remained fit for duty, and a counter-attack delivered by them failed. Reinforcements arrived, but their efforts were in vain, the Japanese erected a breastwork of sandbags on the edge of the craters, and placed machine guns behind it. By evening all the guns in the fort had been dismounted, and at 11 p.m. the garrison evacuated the fort, bearing with them wounded, ammunition, breech blocks, machine guns and provisions. The guns had to be abandoned, as the gorge bridge had been broken down. When the tail of the column was 100 yards from the fort the barracks were blown up with the explosives already placed in readiness in the walls.

Numerous comments have already been made on the folly of building counterscarp galleries exposed to a mine attack without adequate countermine protection. From the point of view of fortification it is interesting

to note the efficient flanking defence afforded to the right flank of North Ki-kwan by the Little Eagle's Nest Battery. Doubtless the Great Eagle's Nest had as efficiently enfiladed the left flank, certainly the Japanese made no advance against that flank although they were in possession of the left end of the salient casemate at the end of October.

As regards the mine defence it seems evident that the Russians were unskilled in this nature of work. It was commenced too late, and the anxiety displayed over the arrangements for the first mine shows that it was considered no ordinary matter. Russian tenacity prevented the Japanese from immediately profiting by their capture of the left end of the casemates, but it is surprising that no attempt was made to countermine the Japanese advance under the front parapet. It cannot be argued that the enemy's fire prevented any work in the fort, since the Russians were able to build a retrenchment, and place obstacles there. In this particular instance borings would have been of immense service, but the Russians had no apparatus.

East Erh-lung Fort was situated on a spur of the Dragon Range. It and Fort Song-shu-shan mutually supported each other. The work consisted of a front and two flank faces with a curved gorge. At the outbreak of the war the ditches, cut in the rock, the concrete



Plan of Fort No. III.—Scale 1 : 2000.

casemates at the forward angles of the counterscarp, and the concrete barracks closing the gorge, were just completed; the parapets had not been built and work was at once put in hand. Those of the front and flanks consisted of the natural rock with 2 to 3 ft. of earth over it. The gorge parapet was on the roof of the barracks, revetted with cement barrels and sandbags. Sandbag loopholes were made on all faces, the front face was also traversed. The left flank was exposed to view and reverse fire from Ta-ku-shan, and in August the banquette was widened, and a parados provided. The right flank was enfiladed from Wolf's Hill, and was given traverses and overhead cover of wooden beams covered with earth.

The terreplein was bare rock, and was covered with 1 ft. of earth. In the centre was a battery for four 6-in. guns, and an observatory tower. Officers' quarters, kitchens, magazines and latrines were all improvised. The front ditch was 21 ft. deep, and 28 ft. wide, the flank ditches sloped up to the gorge, the scarps were all vertical. In the right salient of the counterscarp was an L-shaped block of casemates for enfilade fire along the front and right flank ditches, a smaller casemate in the left salient flanked the left flank ditch. The former was reached by a passage under the ditch leading from the centre of the front face, the inner end of this passage was defended by a guard room. No gallery had yet been built to the casemate in the left salient, this casemate was therefore only approachable from the ditch and was consequently isolated. At the foot of the glacis was a wire entanglement.

It was only when the Russians found their counterscarp casemates threatened by the Japanese that they began to countermine. They first dug a trench in the glacis to defend the right casemate, and placed under it in shafts three mines of 70 lbs. of powder each. On the 26th of October when forced to abandon this trench they blew it up. Two openings were then made in the back wall of the right casemate whence it was intended to drive countermine galleries 30 ft. long, to join them by an envelope gallery, and excavate mine galleries from that. There were only seven sappers available, and hardly any tools for rock cutting, so that work was very slow. On the 28th a sortie was made to try to damage the saps constructed by the Japanese from the trench which had been abandoned and blown up, and which the Japanese had repaired and occupied. Another sortie was made next night, both were unsuccessful. On the 29th the Japanese were heard working behind the right casemate wall, and at 4.30 a.m. next day they blew a hole in it about 7 ft. in diameter and rushed in. The Russians retired by the passage leaving behind two 37-m.m. guns and two machine guns. The passage was then blocked with sandbags and boxes of earth at a point under the parapet. The Japanese wrecked the casemate, and demolished part of the front wall. A general assault was made that day; the columns reached the crest of the glacis, and brought scaling ladders and light footbridges, but these were all too short for the deep and wide ditches. Fire from the fort and adjacent works dispersed the attack. The left casemate had been cut off all day, and that night its garrison fell back into the fort. No countermining had taken place on that side. Although the Japanese advance had been by sap only, yet in a week's time they had won to

the counterscarp; it had been very different at North Ki-kwan where the countermines, although commenced very late, delayed the attackers for three weeks.

The Russians now built two walls of stone in cement to block the passage under the front face; the first, close behind the barricade they had made, was solid except for a listening hole, the second, some yards further back had an opening at the top to throw grenades through, a shuttered loophole, and a manhole at the bottom.

By the 10th of November the Japanese had completed the works with which they crowned the glacis. On that day they blew up the casemate of the left salient, and made preparations to drive a mine gallery under the front ditch. They also attempted to bridge the ditch from the right casemate till a hot fire caused them to cease. On the 17th further attempts were made to demolish the right casemate, but the front wall was only cracked.

On the 18th more sappers were sent to the fort, and placed three charges each of 55 lbs. of melinite under the foundations of the passage guard room, so that it could be blown up if captured. Under the parapet of the left flank, and on the banquette, fougasses, each of 50 lbs. guncotton, were prepared, the electric conductors were buried 18 in. and the ends taken to the barrack. On the 19th, two countermine galleries were commenced, one from the right wall of the passage, between the two stone walls, the second from the banquette of the front face on the left of the passage. The reinforcement of sappers was now withdrawn, and those in the fort only continued the work half-heartedly.

On the 20th the Japanese blew down the counterscarp of the front face in three places, and threw a quantity of faggots into the ditch. Three companies tried an assault which failed. From the 22nd to the 25th several further attempts to cross the ditch were foiled, and the brushwood was occasionally set on fire by grenades, torpedoes, rags soaked in oil and tar, tar barrels, and other combustibles, but the fires were soon extinguished. The Japanese fired a small charge in the exterior slope of the parapet itself to facilitate escalading, and masked their approach from the right salient by a strong sandbag traverse. On the 26th another assault was checked by fire from the retrenchment, and a counter-attack with the bayonet drove the assailants back into the ditch.

On the 1st of December the Russians heard from the passage the sound of Japanese pickaxes, and there was no longer any doubt that the latter were mining under the parapet. Information was also received from Fort Song-shu-shan that the mouth of the gallery was visible, and might even be destroyed by a lucky shot. On the 8th of December owing to the rocky nature of the soil the Japanese had to blast in their gallery under the left salient, the explosions were distinctly audible, and the blows of picks were also heard under the centre of the front face. On the 18th of December a reinforcement of 12 sappers was sent from North Ki-kwan after it had been captured by the Japanese. The Russian countermine galleries were now only 13 and 10 ft. long respectively.

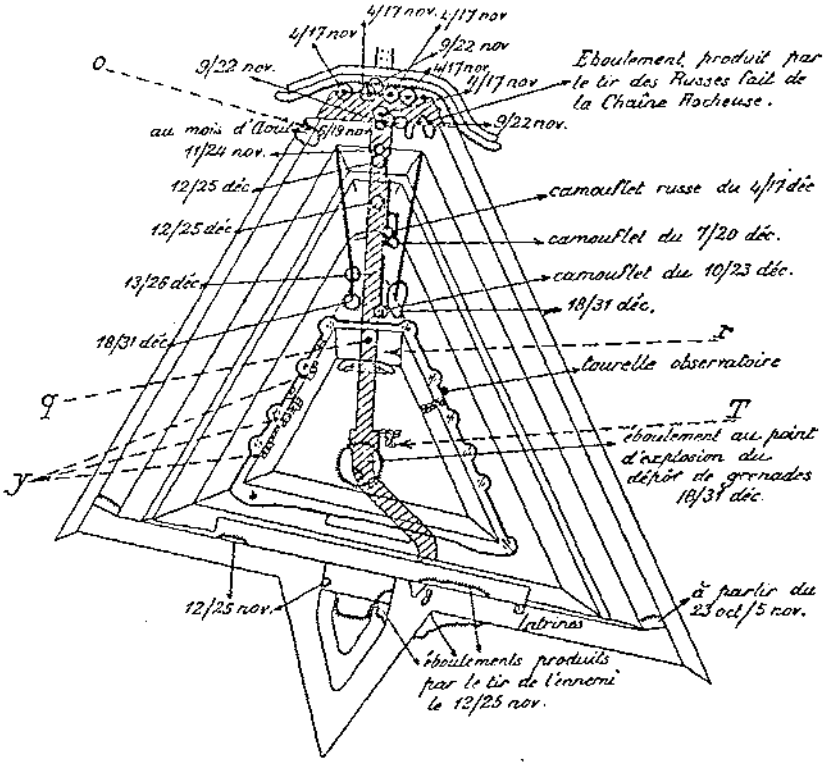
On the 21st of December General Gorbatovski issued an order, based on the lessons of North Ki-kwan, in regard to the dispositions to be made when the front face was blown up. The craters were to be occupied a

once, the troops taking filled sandbags with them. The cover would be better there than further in rear. The men were to be warned that there was nothing to fear from the explosions, and that the escalading would be carried out with some reluctance.

On the 27th the Japanese charged their mines, and, by keeping men at work with picks, completely deceived the Russians as to what was going on. The explosion was therefore quite unexpected. It occurred on the morning of the 28th, and was so violent that the walls of the barracks were shaken and the lights extinguished. Two large craters were formed, one on each side of the entrance to the passage under the ditch, and though formed in rock, the parapet was absolutely shorn off to the level of the terreplein. Large numbers of the assaulting troops were buried under the débris. The fort was shelled vigorously, even 11-in. guns being used. Ensign Poseda collected what troops he could find to defend the front face, but the Japanese held them at bay, and fifteen minutes after the explosions threw themselves on to the parapet. The Russian batteries and forts within range deluged the glacis and ditch with projectiles, but as they were themselves subjected to a heavy fire from the Japanese, their fire was not very effective. The Japanese succeeded in occupying and crowning the craters. Capt. Boulgakov, Commandant of the Fort, twice tried to lead parties from the barracks against the enemy, but the outlets were only wide enough for three men abreast, the Japanese machine guns mowed them down, and the counter-attacks failed. At 11 a.m. the fougasses prepared on the left flank were fired, and attempts were made to fire the charges placed under the foundations of the guard room, but they failed to explode. The central battery was by this time a ruin, but the Russians still held on to it. During the afternoon the Japanese crept slowly on, and at length captured the retrenchment. They now commanded the exits from the barracks, rapidly established flying saps, then a deeper trench in which they placed machine guns. Small parties tried to work round the flanks and turn the gorge, but still Capt. Boulgakov would not give in. At about 10 p.m. Lieut.-Colonel Gandourine, who was in command of that section of the defence, ordered the evacuation of the fort, and made arrangements for removing the wounded. The garrison retreated, taking with them their machine guns, ammunition, and provisions. The evacuation was completed by 2 a.m. on the 29th of December. The bedding in the barracks was saturated with kerosine, and set on fire, and the fuzes attached to some torpedoes stored near the gate were lighted. The bursting of these destroyed part of the passage, and the Japanese, for fear of further explosions, only entered the barracks next day. There remained in the fort three dismounted 6-in., seven 2-in. and a few other guns, which had all been rendered unserviceable before the evacuation.

Fort Song-shu-shan was of similar construction to the two forts above described, but was in trace triangular, with a blunted apex. The right flank was 82 yards long, the left 70 yards, and the gorge 83. The parapets had not been constructed, nor the ditch levelled. The flank ditches were enfiladed by casemates in the apex of the counterscarp, a caponier across the ditch joined these casemates to the fort, and provided flanking fire

for the short front face. To prevent an enemy from using the roof of the caponier as a bridge, it had been intended to fix an iron palisade across it, but this had not been made when the siege commenced. The concrete barrack closing the gorge was a low narrow corridor with barred windows. Opposite the centre and joined to the barrack was a caponier to flank the gorge ditch and containing officers' quarters, etc.



Work No. 3.—Scale 1 : 2000.

To the right of the gorge caponier, on a level with the ditch, was a door leading into the barracks. Opposite this was a passage leading up to the terreplein in the centre of the fort, where were openings to each side, covered by traverses. Beyond these openings the passage descended again to the caponier and casemates in the apex of the fort. Across the terreplein the passage was unroofed. On the outbreak of the war the parapets, and revetment of the counterscarp was hurried on, and above the barracks, under the gorge parapet were placed blindages to serve as kitchens, stores, etc. The garrison was one company and a detachment of artillery. The glacis was surrounded by wire entanglement.

By the end of October, 1904, the fort had already successfully resisted several assaults, and the Japanese were established at the foot of the glacis. It had been proposed in September to countermine from the front casemates, but it was hardly expected that the Japanese could

mine in the rocky soil, workmen and special tools were wanting, and countermining was postponed till the 27th of October, by which date it was evident that the safety of the casemates was imperilled. Two galleries were then commenced from the back of the casemates. On the 30th the Japanese made another assault, but their scaling ladders were too short to reach the bottom of the ditch (28 ft. deep). Their saps had, however, nearly reached the crest of the glacis over the casemates, and from thence they sallied out and threw bags full of rags into the ditch, and returning again, repeated the operation. They then jumped into the ditch and climbed the exterior slope. Received by the fire of the garrison from the parapets and casemate, and by reverse fire from the neighbouring works, they were forced to retreat with loss. During this assault a shell burst in the passage across the fort, killed two officers, one of whom was Capt. Chemetillo, Commandant of the Fort, and exploded a magazine, which caused great damage to the exits from the passage on to the terreplein. Fortunately reinforcements arrived at that moment.

The Japanese now crowned the glacis with a sandbag parapet, and commenced sinking shafts to blow in the roof of the casemates. On the 31st the Japanese ladders left in the ditch were destroyed with torpedoes. On the 5th of November the Japanese were clearly heard working on the roof of the casemate. It was decided to close the openings into the countermines, which had only been driven for about 7 ft. each, and on the 7th the casemates were vacated, and the opening into the caponier was walled up. This work was completed by the 10th, and meanwhile the sinking of the Japanese shafts was interrupted as much as possible by grenades, torpedoes, etc. The Japanese fixed thick wire screens to protect themselves, and many of the missiles burst harmlessly.

Owing to the hardness of the rock the Japanese mines were only ready to fire on the 17th of November. There was one on the roof, and six in the back wall of the casemates. Two of the latter missed fire, but the back wall was pierced and the front wall shaken. On the 18th the Russians retired behind a breastwork which they had built in the passage where it opened into the caponier, and placed a pom-pom there. The Japanese made further attempts to wreck the casemates, and on the 22nd a charge was exploded against the caponier, but did little damage.

On the 26th another assault was repulsed, the Japanese began to mine under the parapet, and the Russians sank a shaft and placed 35 lbs. powder at the end of a short gallery driven through the right wall of the passage just behind their first breastwork. It was to be fired electrically when required, but the wires were broken, and the mine was never used. Meanwhile a duel took place between the Russian pom-pom and a machine gun fixed by the Japanese in the casemate at the outer end of the caponier. Grenades were also used, and the air in the passage could hardly be kept fresh by a diver's pump placed at the outlet into the fort. It was now found that the Japanese were mining outside the right wall of the passage, and on the 5th of December the first breastwork was forsaken for a second about 25 yards further back. Some days later the first breastwork was partly wrecked by the Japanese. Another mine gallery was driven out to the right from behind No. 2 breastwork, and it

and the passage were lighted by electric lamps. On the 6th the Japanese were heard at work in the caponier, and in the parapet of the front face, and it was proposed to make a *sortie* to ascertain what they were doing, but the idea was abandoned. On the 11th various noises betrayed to listeners in the passage the gradual advance of the Japanese. The Russian gallery behind the second breastwork had been driven about 6 ft., and then turned to the front at right angles, parallel to the passage. On the 15th it was calculated that the head was about 5 ft. from the Japanese gallery. A mine chamber was excavated and loaded with 100 lbs. of powder, tamped with sandbags and wooden frames. To prevent damage to the wall of the passage sandbags were piled on the inside and strutted back from the opposite wall. Blows on the wall of the passage deceived the Japanese, who had no idea that a mine was being charged. At 2 a.m. on the 17th the countermine was fired and must have been effectual. Heartrending cries were heard, and numbers of Japanese rushed out of their gallery into the ditch.

From Japanese sources it has been ascertained since the war that the Japanese were working on the following plan. First, by Boules' shafts to demolish the caponier, and second, to make two covered ways in the parapet to enable them to reach the interior of the fort without being hammered by the neighbouring works. To this end they had driven two galleries, one on each side of the passage, from the extremities of the front face. Then perceiving that the fort possessed this passage they drove a third gallery outside its right wall. It was this gallery that was damaged by the Russians.

In spite of careful tamping the passage had been filled with fumes, and could not be entered for half an hour. Nine hours later sounds of mining were heard further to the rear, the countermine gallery was untamped, and a branch commenced at an angle of 135 degrees. Three days later it was about 11½ ft. long, and the Japanese were close enough to be reached by a second camouflet. 70 lbs. of powder was placed in position and fired. The effect on the enemy was insignificant, and owing to poor tamping the passage was filled with smoke. The Japanese were soon at work again, and it was decided to remove the tamping and prolong the gallery, and also to begin another gallery near a third breastwork which had been built across the passage just in front of a vertical through the superior crest of the front parapet. However the Japanese were heard at work outside between the second and third breastworks, and work was concentrated on the new gallery only. This was sufficiently far advanced by 23rd for 40 lbs. of powder to be placed in it and fired. The enemy's gallery was destroyed, and the tamping was so carefully carried out that no fumes entered the passage. On removing the tamping the end of the Japanese gallery was found to be exposed, and a hail of rifle bullets greeted the miners. 20 lbs. of powder was laid in the open and fired, driving back the Japanese. It was decided to bring up a small q.f. gun, and then enter the enemy's mine, but while arrangements were being made the Japanese fired a mine laid on the ground, killing and wounding eight Russians. Work was now suspended on both sides.

The detachment of sappers in the fort had been reinforced on the 20th of December, and fresh galleries were driven right and left from the passage

just behind the third breastwork. The Japanese were heard on the 23rd working on the roof between the first and second breastworks, the latter was therefore demolished in case it might be of use to them. The roof was blown in on the 25th, and grenades thrown into the passage, which produced such a suffocating smoke that the Russians had to retire behind their third breastwork, where a $1\frac{1}{2}$-in. gun had been placed. On the 26th the Japanese fired a mine in the front parapet. Their tamping seems to have been insufficient, and little damage was done, the loopholes were unharmed, and the sentries remained at their posts. Grenades were thrown into the crater, but no assault was made by the Japanese, although they opened a heavy fire on the fort. On the 27th the Japanese tried to enter the passage, and threw in asphyxiating grenades, but the Russians kept them at bay.

By the 28th all the parapets were broken down, and through the earth banks covering the barracks the concrete walls showed in places. The outlet from the passage which was damaged on the 30th of October had been repaired, a sandbag parapet protected it on the right, and after the capture of East Erh-lung it was found necessary to protect the left flank by a parados. Preparations had also been made to blow up the barracks in case of necessity, 10 shafts had been sunk with chambers for 60 lbs. of guncotton each, and were ready by the 30th. On that date the work was violently bombarded. Charges had not been placed in the shafts in the barracks, but were stored under the beds, with detonators and Bickford's fuze ready fixed.

At 9 a.m. on the 31st two explosions sounded from the parapet caused by Japanese mines on either side of the passage. That on the left had little effect, on the right an oblong crater appeared, but still the crest was untouched. However the consequences were most disastrous, the garrison issued in a mass from the barracks, when a soldier struck with his foot a grenade placed in a magazine in the passage. The magazine blew up instantly, killing a large number of the defenders. Besides this, for some reason as yet unexplained, the charges of guncotton placed under the beds in the barracks were detonated and wrecked the whole building, 122 men out of the 250 then in the fort being killed. The Japanese rushed in over the ruins of the barracks and occupied the gorge, and the reinforcements hurried up by the Russians were forced to retire. General Gorbatovski telephoned an order for the garrison to surrender, seeing that it was impossible for more than a very few to save themselves by flight. 128 were made prisoners, of whom 65 were wounded. The subterranean war had lasted two months.

It may be deduced from the foregoing that as a general rule one mine gallery is insufficient. The opponent then has full liberty of action, and can avoid the danger. A system of galleries is required, especially in the case of defence by countermines.

One salient fact in all these operations was the capture, after a comparatively short period, of the casemates flanking the ditches of the three works. Shortly stated the events were as follows:—After the failure of their general assaults in August, the Japanese proceeded to construct regular siege works, in September and in October they again tried to carry the works by assault from a shorter distance but again

failed. At the end of October at Fort North Ki-kwan, after ten days of close approaches they were in touch with the left end of the casemates, and on 30th they obtained possession of that end, but, hindered by the second Russian countermine, one branch of which protected the right half, it took them three weeks to completely capture the whole block. At Erh-lung East, where countermining was not commenced in time, the flanking work was taken on the 30th of October after a week only of close approaches. At Song-shu-shan, on the 5th of November, the Japanese threatened the walls of the casemates, there were no countermines, and the Russians being unable to make any defence had to abandon the flanking work. Comment is superfluous, the courage and stedfastness of the troops is unquestionable, it was only want of weapons, *i.e.*, of countermines, that led to the loss of the forts. A more stubborn defence of the glacis above ground could not have put a stop to the Japanese approaches. On an average, 2,000 grenades a day were used by the Russians besides other projectiles. Numerous sorties were made, which except for small local successes had no real effect on preventing the Japanese progress whether by sap or mine. The result would indisputably have been very different had a sound system of countermine galleries, prepared in peace time, been available from which to initiate a systematic underground defence.

A second fact which stands out clearly is the blowing up of the parapet as a prelude to the final assault. In all the three cases above described the processes were similar. After the capture of the works flanking the ditches successive assaults were attempted, preparations for which were made by constructing passages across the ditch, or by collecting scaling ladders and footbridges. Thanks to the mutual support afforded to each other by the forts, the more fragile implements were rapidly destroyed. The old methods were then resorted to, the counterscarp was demolished forming several roads for columns into the ditch, and heavy masses were poured over the parapet. As a preliminary to the last, the parapet was razed to the ground and thrown into the ditch, and to effect this the Japanese attacked with the spade the dead angles in the ditch, and buried themselves in the parapet out of reach of grenades and other projectiles, their progress only being interrupted by a few hastily constructed countermines. The parapets which had valiantly withstood the heavy artillery were not proof against these methods. The explosions disheartened the garrison while the ardour of the attackers was enhanced, and rushing over the smoking ruins the latter were soon in possession of the conquered fort.

We may here be allowed to diverge slightly from subterranean warfare to emphasize the close connection which ought to exist, during the attack on a fortified position, between the sappers and the infantry. After a lapse of two centuries it is no longer the artillery that must be enabled to close round the work, but the infantry. There are obstacles to destroy, gaps to be made in wire entanglements or other accessory defences, ditches to be filled up, parapets to be blown down, and conquered localities to be made good. All this is the work of the sapper, who precedes the infantry and smooths his path. A thankless task very often, the general public has a tendency to ignore the fourth arm.

At Port Arthur, for the final assault on the works, a battalion of sappers always preceded the infantry, and there is no doubt that success was in a great measure due to the intimate association of the two arms. It is well to lay stress on this fact, viz., that strong bodies of sappers, carefully trained and disciplined to meet the difficulties and complexities of their comprehensive duties, are absolutely indispensable in the attack of fortified positions.

Among various surprises afforded by the Russo-Japanese War must be mentioned the use of mining in field warfare. During the winter of 1904-05 the belligerents were stationary for some months on the banks of the Sha-ho. The distance between the outposts was barely 100 yards. The *Revue du Génie*, 1907, Vol. XXXIV., p. 5, published details of this episode of the war. The Russians held the right bank, the Japanese the left, the latter also held the bridge of the Trans-Siberian Railway, and had organized a bridgehead on the right bank of the river. To capture it the Russians constructed several retrenchments, and then advanced by sap and mine. To meet this move the Japanese drove two galleries, one along the railway embankment against one of the retrenchments, the other against the Russian mine. On the night of 27th February the Russians attacked the bridgehead, and a reconnoitring party of sappers entered the Japanese galleries, securing as trophies several objects left behind by the Japanese in their precipitate flight. The bridgehead was abandoned.

There was another war of mines at the village of Li-chia-pu, where the Russians occupied a fortified retrenchment about 300 yards from the village temple, which was held by the Japanese. In November, 1904, a Captain of Engineers proposed driving a gallery to blow up the temple, but his suggestion was not adopted till the middle of the following January. It then became clear that the Japanese had carried a quantity of earth out of their temple, and subterranean noises were heard. The General accordingly ordered a system of countermines to be prepared in front of the retrenchment, work was put in hand and proceeded at the rate of about 25 ft. a day. By the 24th of February the head of the gallery was rather more than half-way to the temple. Noises were still heard, and the Russians, becoming apprehensive, opened a branch gallery, and on the 27th a Japanese miner's pick pierced the floor of this gallery. Several mine chambers were then made and loaded ; in all 2,000 lbs. of powder were used, and on the 28th the Japanese gallery was destroyed. There had been no means of ventilating the long gallery ; the miners frequently collapsed, and had to be relieved.

The war in Manchuria inaugurated the era of long battles, and without drawing general conclusions from these episodes of the war, it may not be rash to predict that in certain circumstances mines may be used in the attack and defence of fieldworks. Certainly defended positions which form pivots of manœuvre might well be protected by fougasses with electric connections carried underground, the vulnerability of conductors laid on the surface is too well known. Fired at the right time these fougasses might check the impetus of an assault more surely than any other means.

The writer concludes his interesting work by a short discussion of

the probability of a European conflict being of sufficient duration to call for the employment of mining. It may be assumed that, in order to bring the war to a conclusion with the least possible delay, every legitimate means will be employed to defeat the adversary, and of these means mining is certainly not the least. The timely establishment of countermines will provide for the early extension of an active method of defence. In view of this possibility, however important may be the theoretical and historical study of the effects of mines, such study is not to be compared with practical experience. Mine warfare is, without doubt, an excellent way of training officers and men, it develops initiative and a sense of personality. The problems to be resolved are various and call for instant decision, the caprices of powder and the trickiness of soils demand constant study, the anxiety to guard against surprise stimulates listeners and observers, the deductions to be made in regard to the distances of sounds strengthen the judgment, and the old stager will form a correct opinion from one single fact where a beginner would fall into error. Attack and defence by mining should undoubtedly be practised constantly during peace, the lessons to be drawn from it are invaluable.

A.R.R.

REVIEWS.

FIELD ENTRENCHMENTS: SPADEWORK FOR RIFLEMEN.

Written by an Engineer Officer attached to the Imperial General Staff. Edited by E. JOHN SOLANO.—(London: John Murray, Albemarle Street, W. 1s. net).

THIS little work, which is based on official manuals, covers Hasty Fire Cover, Fire Trenches, Communication, Concealment, Obstruction Shelters, Defence of Villages, Woods and Buildings, etc. It is a convenient size, with a good Index. No better idea of its value can be given than the Introduction, which is written by Major-General G. K. Scott-Moncrieff, C.B., C.I.E., R.E., D.F.W., and is as follows:—

I have been asked to write a few words of introduction to this book on Field Entrenchments. The writer, who prefers to remain anonymous, has concentrated on this subject something like twenty years of practical study, acquired partly during the whole of the South African War, in which he gained distinction, partly by close observation of the battlefields of Manchuria, partly by years spent in training cadets, and as an officer in command of a field company of Royal Engineers. I have known him since he joined as a young officer at the School of Military Engineering, where I was then an Instructor, some twenty years ago, and I can confidently say that there is no one who knows the subject better, or more able than he is, to impart to others the knowledge he has acquired.

This work is based, therefore, not on the armchair theories of the student, but on the stern realities of war. Its value has been exemplified in a startling manner during the present colossal strife in North-East France.

The book discusses the field work of the spade in its true relation to tactics. I do not know of any important points that are omitted, though possibly the experience of the present campaign may add some new matter for consideration and cause us to modify others. In one particular—namely, in the use of sapping where two entrenched lines lie opposite each other, and manœuvring is impossible—the teaching in this book has anticipated the present operations.

There is nothing pedantic, nothing superior about the work. While the application of its teaching must be left to individual resource and energy, the knowledge contained in it should enable any officer to instruct his men, under varied conditions of warfare, in an art which has become more and more vital to the many, and no longer the science of the few.

THE SOLDIERS' LANGUAGE MANUAL.

ENGLISH–FRENCH.

By AJAX.—(London : E. Marlborough & Co., 51, Old Bailey, E.C. 3d.).

A SOLDIER fighting in a foreign land has to meet a real and constant difficulty when unable to converse with the inhabitants. The drift of war takes him from where his own tongue is understood and he comes into touch with all classes of people who know nothing of English. The acquaintance of even a few of the most ordinary words and phrases in every-day life, and especially in every-day military life, will not only be an immense help but will render him a far more efficient soldier. Indeed, if by duty or misfortune he gets isolated from his comrades, it may go far to enable him to bring his business through with success, or to secure him succour and relief.

With this in view *The Soldiers' Language Manual* has been prepared ; much thought and care have been exercised in compiling the Vocabularies and Phrases ; and just enough notes on the grammar have been given to help in the formation of simple sentences for ordinary requirements.

For the Phonetic Pronunciation Marlborough's " Self-Taught " System has been used. It is simple and with practice will speedily remove any diffidence in making first attempts to speak French, while with a little attention the sounds of the same language spoken by others will soon be understood. The book will be found very useful to anyone not acquainted with the French language, and its price places it within the reach of everyone.

NOTICE OF MAGAZINE.

RIVISTA DI ARTIGLIERIA E GENIO.

June, 1914.

SEARCHLIGHTS IN FIELD WARFARE.

The following notices, relating to the employment of searchlights in the great units of the Russian Army, for the purpose of diminishing the difficulties of nocturnal operations, are extracted from No. 56 of the *Militär-Wochenblatt*.

Each army corps has a photo-electric detachment which is attached to the sapper battalion of the engineers. The detachment is subdivided into sections as follows:—(*a*). One section for a searchlight of 90 c.m. for the commander of an army corps (1 officer, 6 men, 1 automobile, 1 transport wagon); (*b*), one section for a searchlight of 75 c.m. for the commander of an army corps (1 officer, 31 men, 24 horses, 2 wagons, 6 two-wheeled carriages, 3 cars for provisions and baggage); (*c*), two sections for searchlights of 60 c.m., one for each divisional commander (organized as above for the 75-c.m. section); (*d*), eight sections for searchlights of 40 c.m., one for each infantry regiment (14 men, 2 wagons, 1 one-horse car, and 1 baggage wagon).

In particular cases sections for searchlights of 40 c.m. are provided for mountain troops and for cavalry. With each searchlight there are 3 or 4 microtelephonic sections.

Technical Characteristics.—Luminous intensity

8,630,000 candles for searchlight of 40 c.m.
27,200,000 ,, ,, ,, ,, 60 ,,
42,300,000 ,, ,, ,, ,, 75 ,,

Anyone coming under the luminous cone of the searchlights remains quite dazzled. This happens especially when the light alternates frequently from light to darkness. The light issuing from a searchlight renders inefficacious that of a less powerful searchlight. Clear light, humidity, and rain weakens the illuminating power, and renders observation more difficult. Mist and smoke are not penetrable by the light of the searchlight. Behind a mask of smoke movements and works can be carried on without fear of discovery by the enemy's searchlights. For a station placed at 8 m. from the ground observation is possible at the following distances:—

For searchlights of 40 c.m. against buildings 8 k.m., against men 1·75 k.m.
,, ,, ,, 60 ,, ,, ,, 10 ,, ,, ,, 2 ,,
,, ,, ,, 75 ,, ,, ,, 11 ,, ,, ,, 2·3 ,,
,, ,, ,, 90 ,, ,, ,, 11·5 ,, ,, ,, 3 ,,

The greatest distance is about 14 k.m. for the more powerful searchlights. Light objects, especially on a dark background, appear nearer than otherwise; dark objects (trees, bushes, etc.) appear more distant. Yellow objects appear white; light green objects appear yellowish. Dry roads, mounds, walls, trees devoid of foliage, hedges, telegraph poles become slowly conspicuous. Wet roads and moist ground look misty. Heights and steep precipices become slowly visible and seem higher, while slight undulations are concealed or confused in appearance. Troops in black or white uniforms are easily discernible, those in brown are more difficult, grey uniforms appear only when projected on a grey background. Steel or objects of metal and metal helmets at once catch the eye. Troops on the march are more easily discernible than those halting, troops lying down are scarcely visible. Close formations should not be formed when under the action of searchlights. The eyes of horses shine with a greenish colour even at a considerable distance. Woods and bushes sometimes render observation absolutely impossible.

Tactical Characteristics.—Searchlights of 60 and 75 c.m. are heavy and difficult of transport so that they cannot be rapidly fixed in position. Those of 40 c.m. on two-wheeled carriages with two horses are better in this respect.

Flat and bare country allows of the full utilization of searchlights but causes observation to be more difficult since every part has to be searched. In a covered country the observation is also more difficult, but it is limited to certain determined spots from which the advance of the enemy is probable. In hilly land the numerous spaces in shade favour the enemy's approach. In woody country it is preferable to use light and easily movable searchlights of 40 c.m. in the glades. The best position for the observatory is in front and to the side of the searchlight and about 25 m. from it. The employment of two observatories is recommended; one on each side and connected by telephone with the searchlight. The observation posts should be masked from the enemy and can also be used for change of cover for those with the searchlights. The observer should reconnoitre the ground assigned for observation before nightfall.

Duties assigned to Searchlights.—To search the ground towards the enemy, to illuminate permanently the points which have to be traversed by the enemy; to illumine spots in the enemy's front that have to be swept by fire; to dazzle the enemy; to unite surprise light with fire in order to create panic among the enemy; to deceive the enemy as to the position of the troops by placing searchlights laterally; to assist the working parties and the movements of friendly troops; to transmit messages (visible up to 70 k.m.).

Duties for Offence.—To illumine the direction of the march; to disturb the enemy's works by illumination; to light up the points of attack in preparing for the assault; to light up the points of direction for gaining the positions for assault; to neutralize the action of the enemy's searchlights; to assist in the destruction of obstacles; immediately before the assault to direct the luminous rays behind the enemy's advanced lines in order to discover the reserves; to cover the retreat in event of failure of friendly troops, dazzling the enemy, and establishing a shield of light.

Duties for the Defence.—To light up the more important approaches to the position especially on the flanks; to illuminate certain spots of the ground in front, and to keep the enemy within the luminous cone; to neutralize the action of the enemy's searchlights; to cover the movements of the troops, creating a luminous shield in front of them; to light up the enemy's position so as to facilitate the fire of the guns; to dazzle the enemy during an assault and to interpose before him a luminous zone 150 m. wide; to disturb and confuse the enemy after an unsuccessful assault; to assist the counter-attacks by dazzling the enemy and throwing him into disorder.

Duties for Advanced Posts.—To illuminate the more important approaches; to assist the action of the patrols and advanced posts in reconnoitring and observation services; to aid the combats of advanced posts by dazzling the enemy; to cover the retreat of advanced posts, dazzling the enemy and interposing a shield of light. Troops in movement if halted remain immovable; on the approach of the luminous rays they may throw themselves to the ground. On ground that does not offer any cover it may be advisable to carry leafy branches of trees under whose shadow the men seek cover.

Arrangement and Disposition.—The conditions that satisfy the best position for searchlights are a free field for illumination; favourable points for observation; non-interference with friendly troops; possibility of communicating with the observers working with other searchlights. Heavy searchlights should generally be placed in rear of the friendly troops and perhaps somewhat above them. If this cannot be done, it is advisable to place them on the flanks, or in the intervals. Light searchlights can be placed somewhat in front but in such case should be assured against surprise. Since the sector of illumination does not surpass 60 degrees to obtain good results it is advisable to have one searchlight of 60 or 75 c.m. for each kilometre of front, or two searchlights of 40 c.m. For a regiment in position there should be two heavy searchlights and two smaller ones. According to the number of searchlights available they should be allotted to regiments or detachments. The searchlights are divided into groups, and work in common accord, under the direction of an officer attached to each group, and they should be in telephonic communication with the commander of the sector and with the observer of each searchlight. The commander of a sector should be in touch with each station commander and should keep him informed on the situation, on the scope of the combat, and on his own intentions and should prescribe the exact duties for the searchlights. The chief officer of the group should also know the situation of the contiguous sectors. Everything required to be made known should be transmitted in good time so that there may be sufficient time to prepare the technical arrangements. The same applies to information to be given to the observers. It is necessary to avoid the searchlights interfering with the lights of others in the vicinity. The use of too many searchlights would be likely to diminish their value.

E. T. THACKERAY.

THE JOURNAL OF THE ROYAL ARTILLERY.

This Journal, which was formerly known as the "Proceedings" of the R.A. Institution, contains articles and information on Artillery matters, some highly technical and some general. Articles on general Military topics also appear.

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