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JAN 1914

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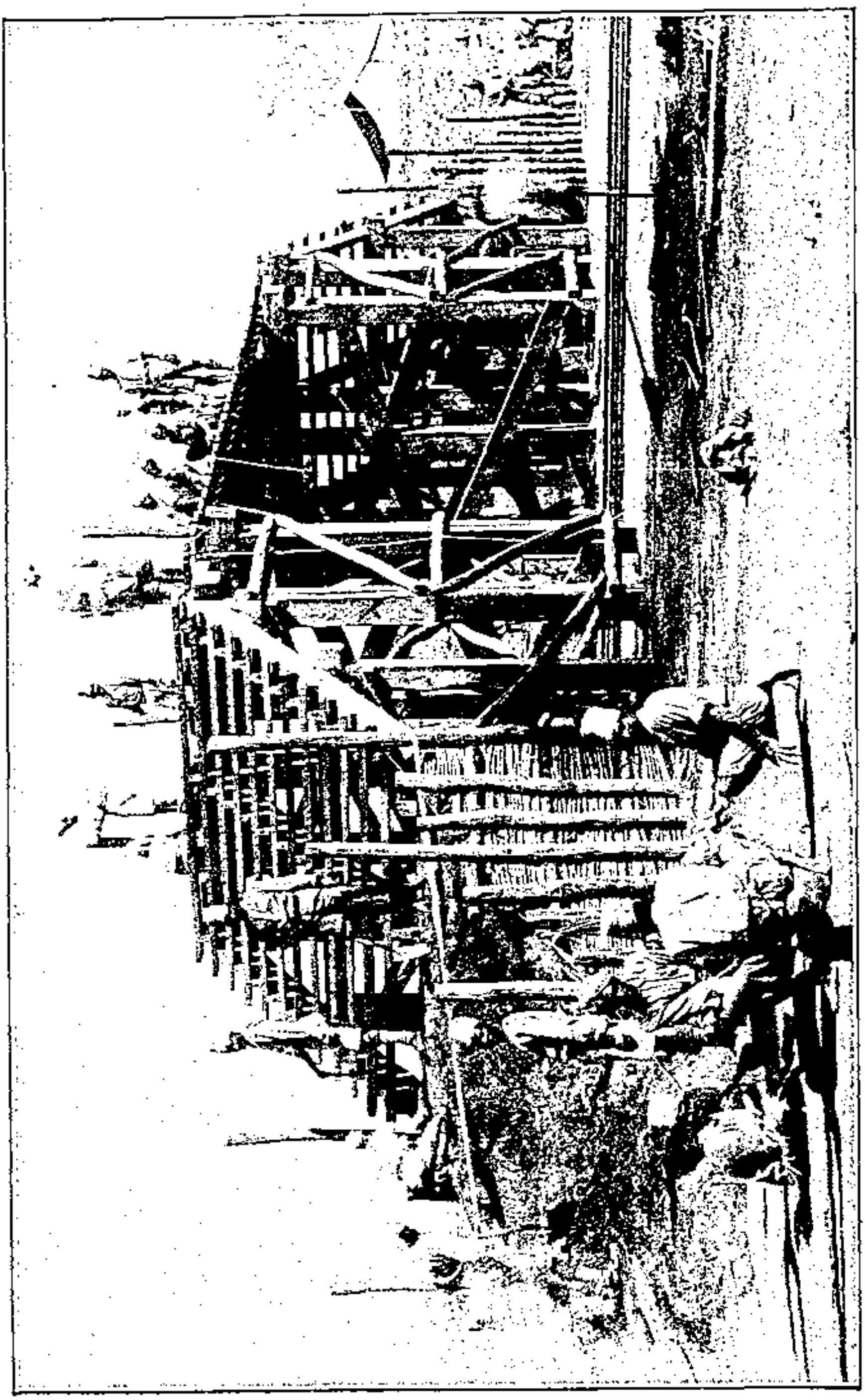


Bridge near rifle butts, constructed by No. 11 Co., 2nd Q.O. S. & M.

DELHI DURBAR, 1911.

By the kindness of the Director-General of Military Works in India, we have been furnished with a series of reports of the Royal Engineer work done in connection with the Delhi Durbar of 1911. In the present number we print an account of that done by the 1st (K.G.O.) Sappers and Miners and by the 26th (Railway) Company, and we propose to reproduce the other reports from time to time in the Journal.

REPORT OF WORK DONE BY THE 1st K.G.O. SAPPERS AND MINERS.

The work done by this Corps may be conveniently classified under three main heads, viz. :—

A.—Work done by detached officers and companies.

B.—Work done by the Corps workshops.

C.—Work done by the Corps when assembled at Delhi from September 29th to December 24th, 1911.

A.—Work done by Detached Officers and Companies.

This consisted of survey work, the marking out of camps, reconnaissance and railway work.

The first requisition for work arrived on 11th January, 1911, when the Commandant was instructed to send a party of 1 British officer, 1 Indian officer and 36 rank and file to work under the A.Q.M.G. in marking out camps. This was followed a few days later by instructions to send two field companies for railway work under the Engineer-in-Chief, Durbar Railways.

Lieut. Hobart, with the party of 1 Indian officer and 36 rank and file referred to above, arrived in Delhi on 1st February. A 4-in. map was urgently required and since existing maps were not sufficiently accurate, an entirely new survey of the Durbar area was necessary. This comprised about 60 square miles.

On completion of the survey, the work of marking out the camps for the civil authorities and Indian chiefs, as well as for the military, was commenced. The total number of camps so marked out was nearly 600. Owing to the failure of the monsoon the numbers of troops were reduced, but the camps were marked out originally for the full numbers, and the necessary modifications were made later.

The corners of the camps were first marked out with flags, which were afterwards replaced by brick pillars, aligned and located by theodolite. All roads and bridges were marked with tarred posts.

This party, with the assistance of three surveyors kindly lent by the Surveyor-General for three weeks, also prepared 16-in. plans of the different areas, on which the exact location and dimensions of all camps were shown. This was also done on the 4-in. map. These 16-in. plans were reproduced by the Corps Press, and the first eight editions of the 4-in. map by the Thomason College. The final edition of this map and its 2-in. reductions were prepared by the Survey of India Department at Calcutta.

On 14th May the party returned to Roorkee, but Lieut. Hobart was appointed Staff Captain and subsequently Officer in Charge of Fire Precautions, in addition to his military duties. On return to Delhi in September, the party continued to work under him on watering arrangements, the erection of signposts, and the laying out of work for pioneer regiments, etc.

In August two officers were ordered to Delhi to reconnoitre the roads between the Jumna and the Hindun, with a view to manœuvres taking place in this country, but these were, however, afterwards cancelled.

The 1st and 6th Companies arrived at Delhi on the 6th February, and were employed under the Chief Engineer, Durbar Railways, until the middle of May. The work consisted of constructing the Durbar Light Railway, for which the survey had been carried out by the Assistant Engineer, Durbar Light Railways.

These companies constructed the whole of the Polo Line, and the Amphitheatre Line up to and including the bridge over the Najafgarh Cut just beyond the station of that name.

In addition to several masonry culverts, two bridges, each of 44-ft. span, were constructed over the Najafgarh Cut, one alongside the Mall Road Bridge, and the other close to Najafgarh Station. These bridges were constructed of iron girders resting on masonry abutments and a central pile pier. The centre pier was constructed of eight piles, 20 ft. long and 10 in. diameter. The piles were driven about 10 ft. into the bed of the nullah and connected together by cross-bracing. Baulks 12 in. by 12 in. were fixed on top of the piles with $\frac{7}{8}$-in. iron dowels. These were laid over each pair of piles in a direction across the stream, two more 12-in. × 12-in. baulks parallel to the stream were laid across them 1 ft. apart for the girders to rest on. These baulks were also fixed with dowels. Each pair of girders had $\frac{3}{4}$-in. round iron ties fixed to the webs to prevent them spreading. The girders were 23 ft. long, with a clear span of 19 ft. 6 in. Eight girders were used, each truck resting on two girders. The roadway was carried by 64-lb. rails, 1 ft. apart, resting on the bottom flange of the girders, and C.I. sheets were laid over the rails. Stone ballast, and 6 in. of earth was then filled in between the girders.

As no pile driver was available ready made up, one was constructed of two 35-ft. 13-in. × 6-in. spars 1 ft. apart, resting on a 12-ft. × 12-in. × 12-in. baulk and stayed with 24-ft. L.M.R. rails. The monkey weighed 1 ton, and a winch was supplied by the railway for raising it. This, however, was not successful and the monkey was afterwards man-handled.

The pile driver having been placed in position, the pile, with four guys attached to it, was placed in its correct position under the monkey. The monkey was then given 1-ft. fall until the pile had sunk 2 or 3 ft., any direction from the vertical being corrected by the guys. Once the pile had been given a fair start in this way, 8-ft. to 10-ft. drops could be given and no difficulty was experienced in keeping the pile straight. Finally 6-ft. drops were given, and the pile was driven until six of these drove the pile about 3 in. only.

When the pier had been completed and cross-baulks and abutments carefully levelled off, the girders were slung into position by means of a 50-ft. derrick erected on one bank.

The bed of the nullah was generally soft but appeared to alter in accordance with the rise and fall of the Jumna.

It was found when making the second bridge near Najafgarh Station that the 20-ft. piles were not long enough and sank a considerable distance under the influence of their own weight, and when they had reached the necessary level, a 6-ft. drop drove them 2 to 3 in. 30-ft. piles were then ordered and arrived a week later. It was then found, however, that the bed had hardened and 20-ft. piles would probably have been sufficient. The 6th Company completed this bridge in a week after the arrival of the larger piles.

B.—Work of Headquarter Workshops.

As soon as the first programme of work at Delhi and the designs of bridges had been prepared, work was started in the shops. The bolts and nuts and dog spikes for all the Jumna and nullah bridges were made up, and these numbered in all nearly 5,000.

Notice boards were made up for the A.Q.M.G. on payment, and a very large variety of small work of all sorts was turned out. This would be difficult to particularize. After the Corps had proceeded to Delhi the Shops also supplied several hundred pick, mamootie and axe helves for the use of pioneer regiments at Delhi, and also lent wheelbarrows, etc., for the work there.

On the 25th October orders were received for the supply of church furniture. This was all made and despatched at 7 p.m. on 5th December.

The Press did all the printing for the notice boards for the sign-posts at cross roads, prepared copies of the 16-in. map, and turned out a large variety of small printing orders. The greater part of the workshops out-turn for Delhi came from the temporary workshops which were established there in September.

C.—WORK CARRIED OUT BY THE CORPS WHEN ASSEMBLED AT DELHI FROM 29. 9. 11 TO 24. 12. 11.

In March, 1911, the Commandant discussed with the A.Q.M.G. at Delhi the nature and scope of the work to be done by the Corps for the Durbar.

It was then decided that the following bridges were required:—

Four bridges for infantry in fours over the Jumna.
Three bridges for infantry in fours over the Hindun.
Six bridges for infantry in fours over nullahs in camping area.

Two of the latter were to be capable of carrying an 8-ton steam road roller.

The Commandant divided up the work between company commanders, who prepared designs and estimates for the bridges allotted to them, and the work of purchasing and collecting material was started at once.

For the Jumna and nullah bridges 1,200 sleepers, 4,500 bullies, 500 $42\frac{1}{4}$-lb. rails were collected by the N.W.R. at Chandrawal, where the field park was established. The sleepers and bullies were purchased locally. L.M.R. rails for use as roadbearers of the Jumna bridges were lent by the Corps and stacked at Wazirabad.

For the Hindun bridges 250 sleepers and 350 bullies were supplied from store at Roorkee and floated down the canal in rafts as far as Muradnagar. From here they were taken on country carts to the sites of the bridges at Sarora and Nekpur. All necessary bolts, nuts, dog spikes, etc., were made up in the instructional workshops at Roorkee.

In August, manœuvres were cancelled and the numbers of troops reduced. This did away with the necessity for Jumna and Hindun bridges and some of the nullah bridges, and the A.Q.M.G. prepared a new programme of work as follows :—

Three overhead bridges to take infantry in double column of fours.
Four 60-ft. fire observatories.
Four nullah bridges to take infantry in fours, one being capable of carrying 8-ton roller.
One bridge over Jumna below the fort for use of visitors to Badshah Mela.

This programme the Commandant accepted, and undertook to carry out the work with the funds previously allotted for the first programme.

The strength of the Corps at Delhi was as under :—

Headquarters and B Company.
No. 2 Company } from 29. 9. 11 to 24. 12. 11.
No. 6 Company }
No. 5 Company from 29. 9. 11 to 11. 10. 11 when they mobilized for the Mishmi Mission.
No. 4 Company less one section October 31st to 24. 12. 11.

In addition the 11th Company of 2nd Q.O. Sappers and Miners were detailed for work under the Commandant, and three sections arrived on 30. 9. 11.

Lieut. E. C. Whiteley was lent by the 3rd Sappers and Miners and was with the Corps during the whole time it was at Delhi. The services of Lieut. E. G. Kitchin were subsequently lent by the Director-General Military Works.

The heavy rains on the 26th, 27th and 28th September had flooded the camp already pitched by the advance party, causing some thousands of rupees worth of damage to the property of officers, Officers' Mess, and of the Corps.

On arrival on the 29th September the Corps had to pitch a new camp on the high ground near Dhairpur village, and until the 2nd October the men were employed in salvage work in the old camp and pitching tents and making roads in the new one.

On October 3rd the work of moving material from camp, from the Engineer Field Park and from the Coronation Durbar Power Station to the sites of the various works was commenced. Owing to the light railway having been flooded no trains were running, which retarded the collection of material. The Executive Engineer kindly placed one track of the line from Chandrawal out to the Amphitheatre at our disposal, and materials for all bridges adjacent to this line were man-handled on construction trollies along it.

Materials for other bridges and observatories were moved in the Corps pontoon waggons, which had been sent down with pontoons and other stores by road.

The new programme of work as received in August, was being continually added to, and fresh demands kept coming in, even after the arrival of H.I.M. the King-Emperor.

The work eventually carried out was as follows :—

Overhead Bridges.

One over four tracks broad-gauge and two tracks light railway, length 150 ft., roadway 10 ft.

One over two tracks broad-gauge and two tracks light railway, length 70 ft., roadway 20 ft.

One over two light railway tracks, length 25 ft., roadway 20 ft.

One over two light railway tracks, length 25 ft., roadway 10 ft.

Nullah Bridges, Span 6 ft. to 120 ft.

Two to take infantry in fours.

Two to take infantry in fours in double column.

One to take 8-ton steam roller.

One to take foot passengers 5-ft. roadway.

Fire Observatories.

Four, one of which was given an outside staircase, necessitating considerable extra work.

Jumna Bridge.

This was required by the Mela Committee with a 16-ft. roadway, and, as pontoons did not lend themselves to this, a double bridge was constructed. This was washed away and a third bridge constructed.

Miscellaneous.

The Flagstaff Tower, which was used as an observatory, was provided with a roof.

Preparation of church parade site and furniture.

Erection of flagstaff in Amphitheatre.

Erection of signalling beacons and flagstaff on review ground.

Work in shops, and supply of materials and tools to pioneer regiments.

The trestles of the overhead bridges were rather heavier than necessary, but the design was necessitated by the materials available. For the bridges over the broad gauge the clearance from the centre of the track to the nearest obstruction was laid down by the railway authorities as 7 ft. The distance from centre to centre of tracks was 15 ft. 6 in., so only 1 ft. 6 in. remained spare for the trestles.

It was thought at first that as the trestle between tracks could not be stayed in a direction at right angles to the tracks they might not be rigid and 1 ft. of concrete was rammed in round their feet. This, however, proved unnecessary, as the weight of the trestles and roadway was sufficient to ensure equilibrium.

The clearance from the top of the rails was 14 ft. 6 in. for the broad gauge and 12 ft. 6 in. for the light railway, but where bridges crossed both a clearance of 14 ft. 6 in. was given throughout. The trestles were first made up complete for each bridge and foundations prepared. The trestles were then all erected and temporarily fixed vertically in position with bullies spiked across the tops on each side between adjacent trestles, and earth was rammed in round the feet. This could be done without interfering with traffic, and it only took 10 to 15 minutes to get a trestle in position.

The roadbearers consisting of 24-ft. $41\frac{1}{4}$-lb. rails were then hauled up and bound in place with No. 14 gauge wire. To give rigidity the rails were bound together in pairs one with the top and the other with the bottom flange uppermost. The roadway was made of sawn sleepers, or, in the case of 10-ft. roadways, pontoon chesses. To save expenditure of sleepers where appearance was not of great importance, the lower flight of steps was made of earth revetted with gabion bands and grass, or split bamboos, *vide Photo* in *Frontispiece.*

The usual design for nullah bridges was that shown in *Photo* (Bridge S). The third bridge shown was used for the steam roller and was constructed with girders supplied by the railway authorities on piles already driven by them in anticipation of the light railway crossing this nullah. A sleeper deck was laid temporarily to take the roller across, as the roadway, which was 7 ft. without it, was not wide enough. The method of fixing the roadbearers, which consisted of L.M.R. rails, proved rapid and effective. The trestles were placed 11 ft. $2\frac{1}{2}$ in. apart centre to centre so as to bring the fishplate holes at the ends of the rails opposite one another over any trestle. A $\frac{3}{4}$-in. iron rod was then placed through the fishplate holes and fixed down at each end with staples. To prevent any spreading, a few rails in each span were spiked to the transoms in addition.

The uprights of the fire observatories consisted of E.L. standards kindly lent by the Electrical Engineer, Durbar Installation, who also supplied all the necessary cross-bracing for them. The observatories had a flagstaff and electric light covered with red gauze for signalling the outbreak of fire. By day a red flag was run up and by night the lamp was switched on.

There were eight standards for each observatory and they were erected in pairs. In the first instance, after raising one pair, it was used as a derrick for lifting the three remaining pairs, but this was found unsatisfactory as it threw the original pair out of the vertical. Subsequent pairs were raised by a derrick. The derrick was then removed and each pair cross-braced. To carry the roof, bullies were fixed into the tops of the standards. The floor was laid on three pairs of sleepers laid across the top horizontal bracing, the centre pair being bolted to it.

Except in one instance, the staircases were erected inside the uprights. In the case where the staircase was made round the outside, the platforms were at the top of each length of the standard, and were supported on two iron brackets at right angles to one another clamped to the upright. This was only put up as a specimen, but was not approved. On completion, all iron and woodwork was painted white, except the outside of the roof which was painted brick-red.

Fear had been expressed by the Durbar Committee that these observatories would be unsightly, but when complete and painted they were far from being so.

Jumna Bridge.

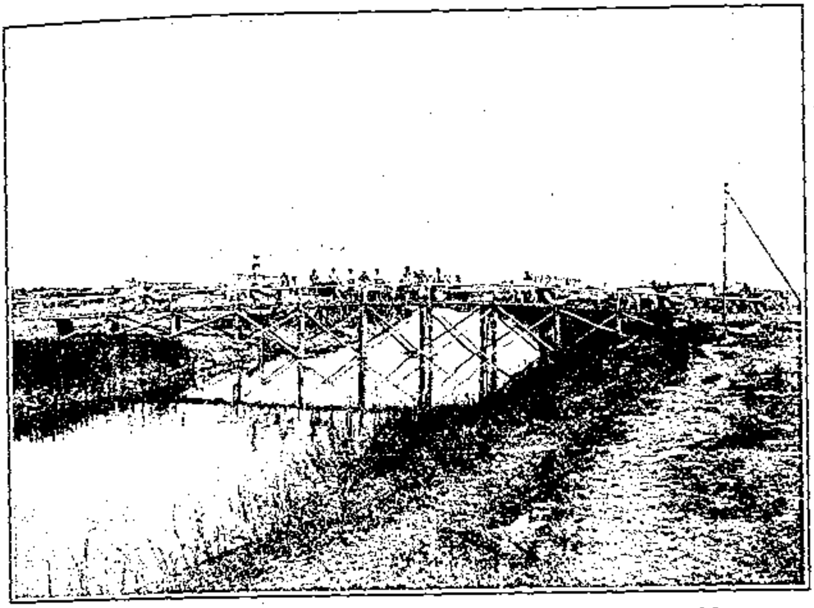
The original demand was for a bridge with 10-ft. roadway, but the Secretary of the Badshah Mela stated that at least a 16-ft. roadway would be required.

Before starting the work the canal authorities were asked what would be the probable rise or fall of the river, and after consulting the records in their possession extending over 50 years, they stated that there was no chance of a rise, and that the river would fall 1 ft. 6 in. to 2 ft. before the date on which the bridge was required.

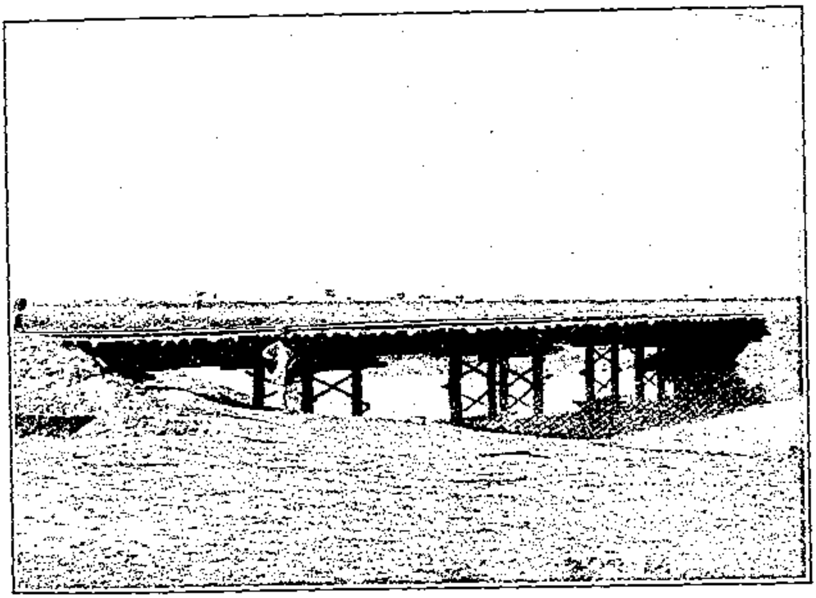
As funds were limited, a site was chosen giving the least span to be bridged. At this point the river ran in three channels one of which could be ignored as there was only 6 in. of water, the other two were 185 ft. and 77 ft. across respectively. This site was only feasible provided the river did not rise, and on the report of the canal authorities it was considered safe to ignore the possibility of this.

The materials available were 8 pontoons, 14 Weldon trestles, 60 15-ft. pontoon baulks, 12-ft. L.M.R. rails, 375 chesses and 10-ft. chair sleepers for the remainder of roadway. No. 14 gauge wire for lashings and sâl bullies in any numbers. As pontoons did not lend themselves to a 16-ft. roadway it was decided to make a double bridge of 10-ft. roadway over each span.

The work was given to No. 4 Company, consisting of three sections only, and they left camp for the site of the bridge on the 13th November, 1911. The bridge was completed over the two channels on the morning of the 22nd November and the company marched back to camp.



Bridge S.—Constructed by No. 6 Co., 1st K.G.O. S. & M.



Steam Road Roller Bridge.—No. 2 Co., 1st K.G.O. S. & M.

Just after the company started back information was received that the river was rising. The O.C. enquired at the canal office as to the cause of this and whether the rise was likely to continue. The canal authorities assured him that he need have no apprehension, as the rise would cease immediately. However, the river continued to rise for two days, the total rise being 3½ ft.

The flood, due apparently to an unprecedented fall of snow and rain in the hills, arrived too rapidly for demolition to be possible and the bridge had to be left. There was about 150 ft. of water between the ends of the bridges and the shore and about 2 ft. over portion of the bridges. In spite of this, owing no doubt to the weight of the rail roadbearers, the bridges stood.

Unfortunately the river did not fall as rapidly as it had risen. It started falling on the 25th November, but only fell at the rate of some 1½ in. a day. As the Durbar started on 7th December immediate action was required. So on 28th November, 1911, the company returned to camp by the river and started demolishing the four bridges. As the trestles had by this time sunk some 4 ft. or 6 ft. into the sandy river bed, and anchors were also buried deep, and the roadway some 2 ft. 6 in. under water, the demolishing was no easy task. The trestles had to be hauled out with tackle.

It was decided to build a new single-bridge 10-ft. roadway some half mile further down stream. Floatable material was floated down and heavy material carted. Owing to various detached parties, only some 70 men were available for work. The new bridge was started on the 1st of December and completed at 8 p.m. on 6th December, after which the company marched back 8 miles to their camp in the Durbar.

Accompanying sketches show section of bridge and type of trestle constructed.

Notes on Bridges.

Trestles.—This type of trestle was found very convenient. As the trestles never sank to the same depth in the shifting sandy bed, transoms had always to be adjusted afterwards. With the type of trestle used this was easily managed especially as care was taken that the transoms, before adjustment, were always higher than necessary. The difference in time and men required to lower or raise a transom is enormous, and if transoms cannot be fixed at the right height before launching it is as well to make sure that they are too high and not too low. Trestles sank on the average some 2 ft. into the sand.

Construction.—A 2-in. steel cable was erected as a flying bridge across the river some 50 ft. up stream. Building was carried on from both ends simultaneously. All trestles were floated out, being attached to the steel cable as in *Diagram* 4 on *Plate* and pulled out from opposite bank. When opposite their position, the trestles were floated down stream by letting out the rope passing through the block on the steel cable.

Two long spars were used as ways, with foot-ropes attached to the up-stream leg of last trestle in position as in *Diagram* 5 on *Plate*, one man on each way was able to keep them in position.

The trestle was then hauled up the ways some 5 ft. and two bights of a rope, fixed to a 3-in. rope passing to the opposite bridgehead, were thrown over the leg heads. A party on the opposite bridgehead then hauled the trestle up into a perpendicular position. This method saved an immense time as the trestles were too heavy to be easily pushed up by the usual method with hand rails.

Erection of Flagstaff in Amphitheatre.—This consisted of two spars of 90 ft. and the other 50 ft. in length. It had been sent up from Bombay by rail and the dockyard authorities also sent two 50-ft. spars and tackle for erecting it.

Lieut. Headlam, R.I.M., was responsible for its being correctly put up as regards all naval matters and had drawings showing the arrangement of foundations and rigging. This drawing showed the butt of the flagstaff resting on concrete foundations 10 ft. below the ground level. However, on reaching 4 ft. water began to appear and it was decided to reduce the depth of foundations, the excavation for which by means of a coffer dam of planks and use of a pump was carried to 6 ft. 10 in.

As there was no time to make alterations in the event of failure due to subsidence of foundations, and since the amount of ballast available was limited, the following arrangement for the foundations was adopted :—

Twenty-five bullies 6 ft. long were driven as piles in a square of 4-ft. sides, till flush with the bottom of the excavation and they were all carefully levelled.

Mauls were at first used for driving the bullies but these broke and a Norton tube with monkey and pipe was borrowed from the P.W.D. This saved all further trouble and the bullies were quickly driven. A sleeper platform 10 in. thick and 50 in. wide was then made up of sleepers bolted together. On the top of the platform chocks were fixed for the butt of the flagstaff to slide in between. Iron sheeting was screwed down between the chocks and well greased to prevent friction. This platform was placed on top of the piles, carefully centred and wedged in position with sleepers backed by concrete. Owing to the presence of water, cement concrete was mixed dry and put in in sand bags. A ramp was made down to the platform and the lower mast laid on the ground with its butt projecting over the ramp just short of the edge of the platform.

Foot-ropes, etc., were attached, and the mast raised, the head being first raised with a 30-ft. derrick, and the strain was then taken on sheers and the mast raised to the vertical. The foot-ropes were let out as required and the mast slid into its position on the platform without any trouble. The advantage of the form of foundation adopted was that once the mast was erected it was in its correct position and required no subsequent shifting. The top mast was raised in the usual manner with tackle rigged to the lower mast. Some delay occurred in this, as the men working at the top of the lower mast, not being used to the work, allowed the lifting rope to get out of the grooves, thus causing a jam. However this was righted and the rigging was finished off to the satisfaction of Lieut. Headlam.

Erection of Signalling Beacons and Flagstaff, Review Ground.—For use at the Review to ensure all troops acting together, the A.Q.M.G. asked for a ball 6 ft. in diameter that could be raised or lowered at will, to be erected where it could be seen by all troops on parade. The ball was made up of a frame of split bamboos with an iron rod through the centre and canvas sewn on the outside, the whole being painted black. An E.L. standard was borrowed from the Electrical Engineer and fitted with a bracket at the top, 4 ft. in length, and was erected in rear of the pavilion post. It was tested at the rehearsal and worked well. The authorities were, however, afraid of failure, and a second was asked for and erected, but was not used.

Flagstaff.—The flagstaff provided for use was 40 ft. in length, and in three pieces, most of the joints being loose. As the appearance of this flagstaff was not very satisfactory, permission was asked to erect a flagstaff consisting of an E.L. standard with the top of the mast let into it. This was obtained, the standard was painted with white ripolin, and the iron fittings and the truck gilded. Half-inch wire rope guys were fitted with screw-tightening shackles fastened to chains attached to buried holdfasts. This gave a flagstaff over 50 ft. high which was the minimum height possible to carry the silk Royal standard provided for the occasion.

An unfortunate accident occurred owing to the sheaf of the truck breaking just as the King-Emperor arrived, and this caused some delay in breaking the standard.

Church Parade.—The ground for the church parade was marked out, and profiles of the various banks made. The actual earth-work was done by the pioneers. Arrangements for the supply of bricks and bajri for the paths were kindly made by the Garrison Engineer, Delhi. All the furniture was made up in the Roorkee workshops.

Workshops at Delhi.—Work in these was carried out under the Superintendent of Instruction.

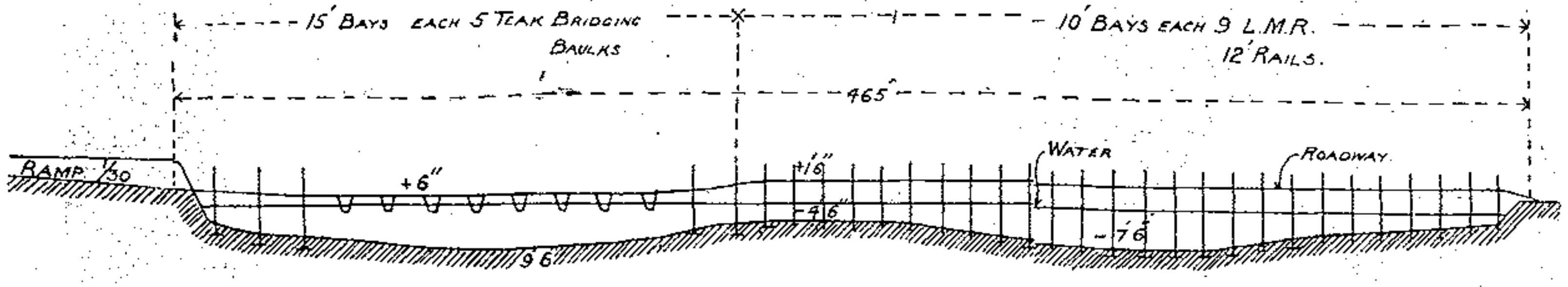
The work for the Durbar consisted chiefly in making signboards, map boards, beacons, etc., and the following is an approximate list of the work carried out:—

200 Signboards.
250 Notice boards.
80 Map boards.
500 Small boards with names of regiments, etc., painted on them.
8 25-ft. beacons for Review ground.
2 Signalling beacons for Review ground.
1 Flagstaff for Review ground.

In addition several small jobs in connection with the bridges were carried out, whilst the supply of materials and tools for pioneer regiments was arranged for. In addition to the above it was found possible to carry out a good deal of private work, such as shoeing, repairs to traps and minor repairs of all kinds for officers of different regiments at Delhi.

DELHI DURBAR, 1911.

JUMNA BRIDGE.



SECTION.

DETAILS.

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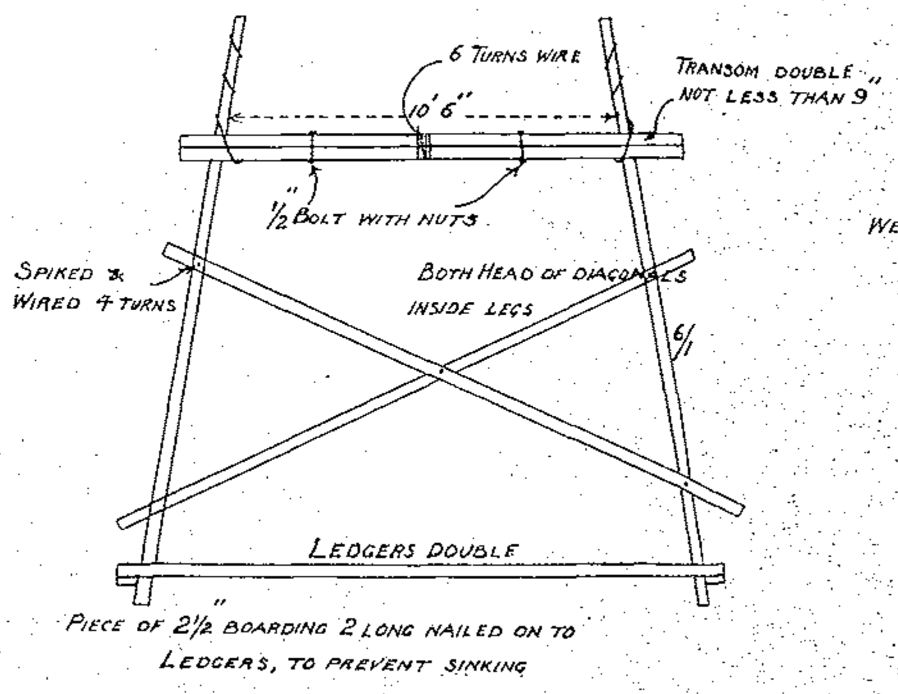

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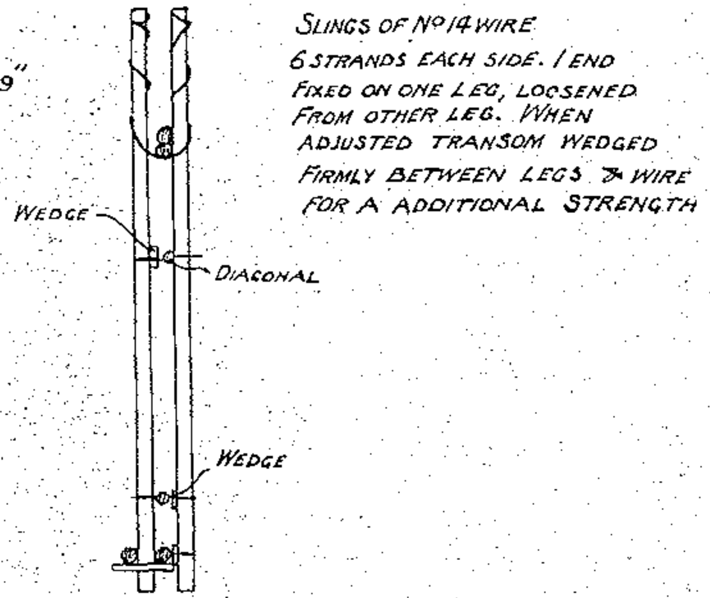
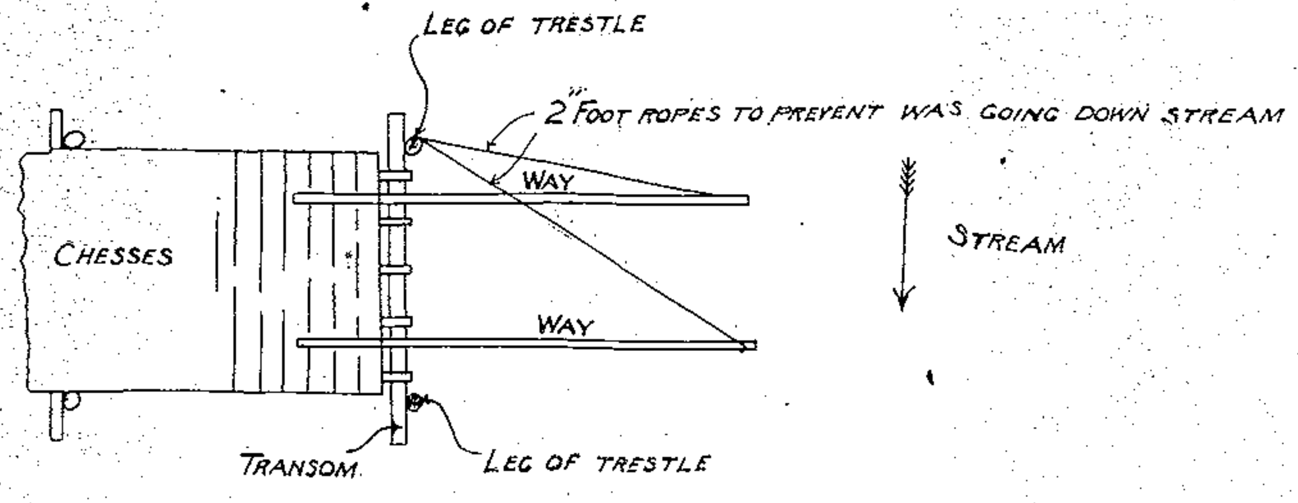


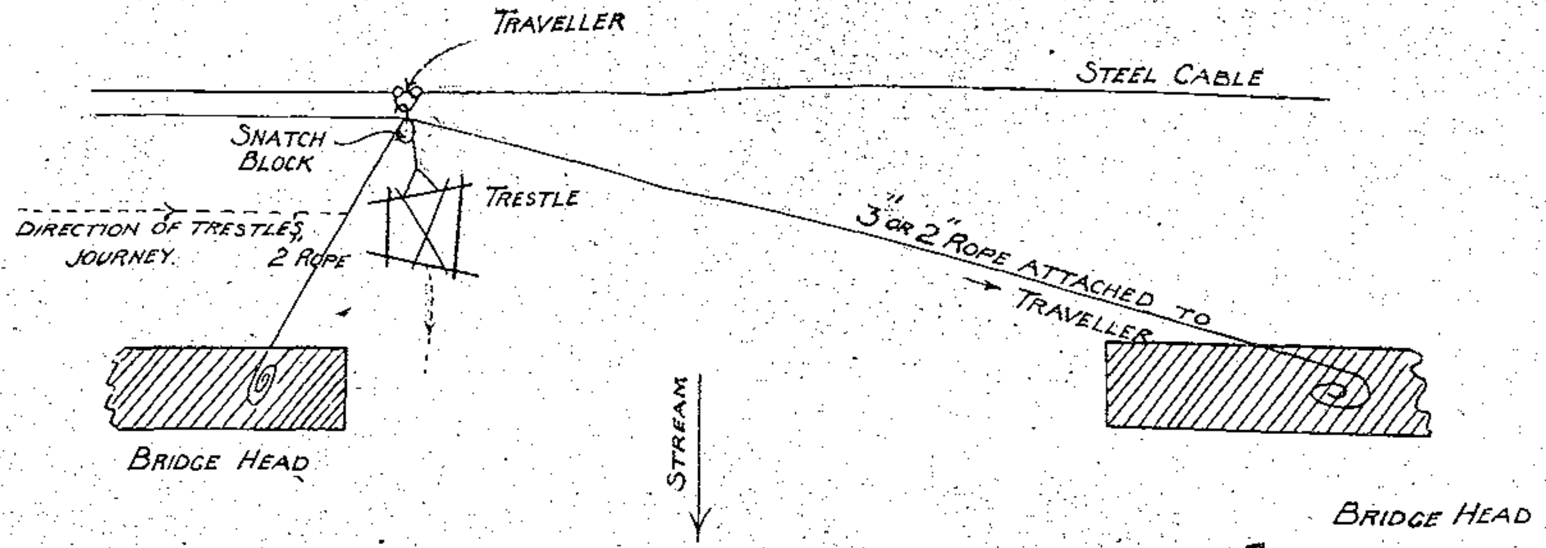
CROSS SECTION.

SHOWING WAYS & THEIR FOOT ROPES. DIAGRAM 5.



TO SHOW HOW TRESTLES WERE FLOATED OUT

DIAGRAM 4.



THE WORK DONE BY THE 26th (RAILWAY) COMPANY, S. & M., ON THE DELHI DURBAR RAILWAY, 1911–12.

By LIEUT. G. D. RHODES, R.E.

THE 26th and 25th (Railway) Companies, S. & M., are permanently employed by the N.W. Railway. The 26th Company has been employed on the maintenance of the Sialkote-Jammu branch since 1909. This branch had previously been maintained by the 25th Company.

Preliminary.—The order to proceed to Delhi was telegraphic and was received on 13. 5. 11. The only previous intimation which had been received was a letter from the Engineer-in-Chief, Delhi Durbar Railways, asking whether the company could arrive by the 1st September. Acting on this information, men were sent on furlough at once, and arrangements to begin musketry made. Engineer-in-Chief's telegram upset all these arrangements (except furlough, which was not cancelled, being one year overdue). A little difficulty arose on the eve of departure owing to the management of the railway not having informed the G.O.C., 2nd Division, of the intended move. The company was ordered to stand fast by the G.O.C., Sialkote Brigade. The required permission to proceed was received after an exchange of long wires at 20 hours on 26. 5. 11.

The Sialkote-Jammu branch had not been run by civilian labour since 1902, but in spite of this and the fact that it was the harvesting season, the men were replaced by civilian labour throughout, all works were measured up to date, and the sub-division was handed over on 20. 5. 11.

The men were allowed on leave in big batches in order to settle their home affairs and the company was ready to depart on the evening of the 25th.

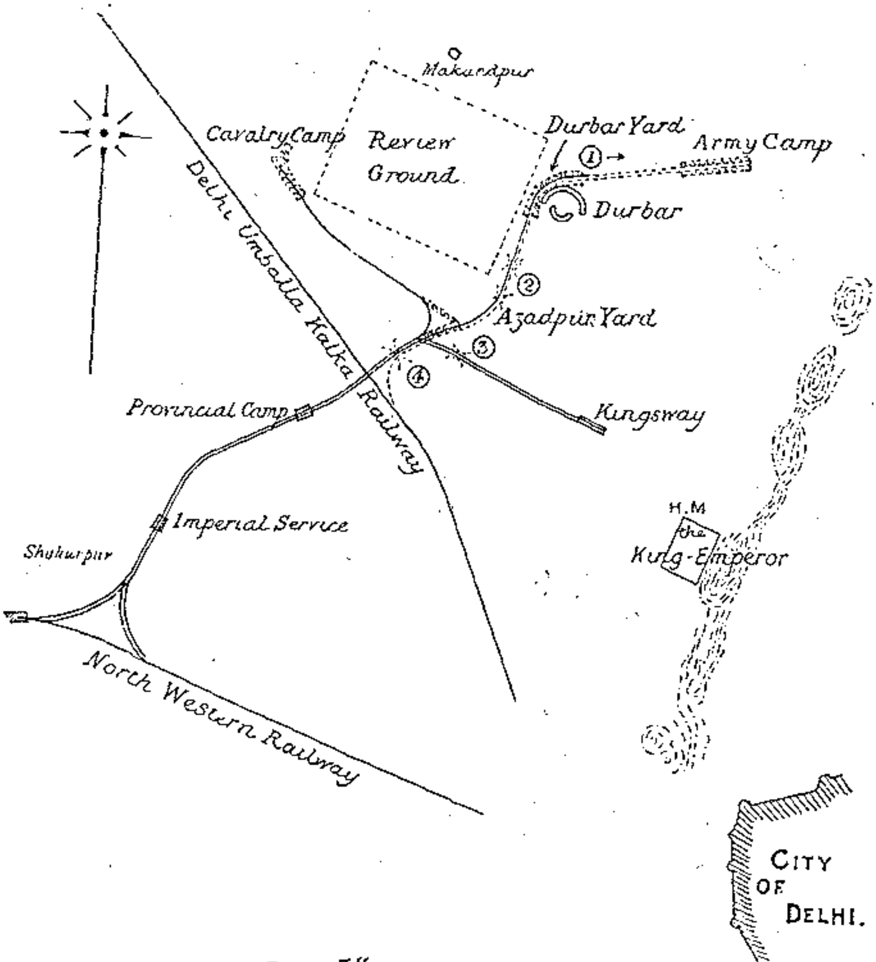
No information as to camp site, or even situation was furnished beforehand, in spite of several telegrams, so that an advance party could not be sent. Neither was the O.C. informed as to the nature of the work to be done beyond the fact that the company was to be employed on contract.

The move was easy, as a special mixed train was put at our disposal

24 hours before the time of departure. The company was thus enabled to load the train the day before. All stores and tools and plant were taken to Delhi as it appeared unlikely that the company would return to Sialkote, the annual relief taking place in the next trooping season.

The company entrained at 9.30 a.m. on 27. 5. 11; arrived, and were detrained, at the site of their future camp at 6 a.m. on 28. 5. 11, strength: O.C., Lieut. Fraustadt, R.E.; 1 B.N.C.O.; 2 N.O.'s; 1 doctor; 165 rank & file. They were met by Mr. Lyle and Mr. Owen, under whose orders they were to work. The journey down was enlivened by a fire in an open truck full of charpoys, etc., which was promptly dealt with.

DELHI DURBAR RAILWAY, 1911, ON MAY 30TH.



Scale $\frac{3}{4}''$ = 1 Mile

WORK DONE BY 26TH (RAILWAY) COMPANY SHOWN DOTTED.

Camp.—The site of the camp was excellent in all respects but one. It was impossible to drain it really satisfactorily. It had previously been occupied by the 128th Pioneers. The water supply (well) was plentiful and excellent, and remained so throughout the hot weather. The men were first housed in the mobilization shouldaris but after a week I.P. tents were received. A latrine of 14 seats was built of C.I. sheets, old C.I. cot planks and sleepers; and a circular incinerator of brick with an iron fireplace in the centre. This worked very satisfactorily. A "chappa" shed was built as a stable. Altogether the camp was very comfortable. Some difficulties about supplies was experienced at first, owing to the S. & T. refusing transport on the ground that the company was "on contract."

Work.—Work was started on 30. 5. 11, and up to 1. 11. 11 it consisted of:—

Construction of Line.—The map on preceding page shows the lines laid by the company. As stated above the company was working under Mr. Owen, who was Executive Engineer of the part of the Delhi Durbar Railway north-east of the Delhi Umballa Kalka Railway. All yards were laid by the company except Kingsway.

The Sepoys were organized in 12 gangs of about 14 men in each, tradesmen excluded. The coolies in gangs averaging 15 strong, each under a lance-naik. When linking, the disposal was roughly as follows:—

Coolies unloading and spreading sleepers	30
Coolies unloading and spreading keys, chairs and spikes ..	10
Sepoys unloading and spreading rails	15
Carpenters punching auger marks	6
Augerers	20
Hammermen	12
Linking	12
Spannermen	6
Keymen	32
Total ..	153

These figures are approximate and include only "workers." N.C.O.'s are not in the count. The proportions varied from day to day according to the lead, disposition of load on ballast train, whether railhead or doubling, etc. Gangs were changed round about once a week. Working hours were 6 to 12 hours and 17 to 19 hours—8 hours in all.

Saturday evenings were spent in drill and every alternate Sunday was a holiday. The men proceeded to and from work in the ballast train when available. Parade before work was in camp and dismissal from work at site.

About 10 miles of line have been laid. The work commenced at (1) (see map). Army Camp was completed first in rather a hurry, as the Irrigation Department wished to close their bund (built to restrain the expected flood of the Jumna, which never came) which crossed the line right across what was afterwards Durbar Yard.

The line was then doubled from Azadpur to Durbar, except the Azadpur end where a diamond crossing was awaited for over two months. Durbar Yard was next completed as far as the bund allowed. The scene of work then shifted to Cavalry Camp, which was completed by the 10th of September, after a great deal of trouble with the "island lines," owing to the platforms having been built first at an angle slightly wrong. Nearly 20 days were spent slewing the lines here and there trying to make them fit into the platforms; but finally the platforms had to be moved. The extraordinary plan of the yard was due to the intended Mokundpur line, which was never built. The work throughout was never continuous but proceeded as material arrived, the men being in the meantime "employed as requisite."

The majority of line was 73-lb. B.H. rail on 40-lb. chairs and wooden sleepers. The remainder was made up of (about 2 miles) 73-lb. B.H. rail on 45-lb. chairs and wooden sleepers; (about $1\frac{1}{2}$ miles) 68-lb. B.H. rail on 40-lb. chairs and wooden sleepers; (some) 62-lb. F.F. rail on steel sleepers; (some) 87-lb. F.F. rail on wooden sleepers; (some) 75-lb. F.F. rail on wooden sleepers.

Sleepers Used.—Deodar, new; deodar, S.S. (some very bad); jarrah wood, new; jarrah wood, S.S.

Crossings.—Majority were 75-lb. F.F. $1:8\frac{1}{2}$ and $1:12$. Remainder 75-lb. D.H. block, $1:10$; 60-lb. D.H. block, $1:10$ (for which a little D.H. rail had to be used); 90-lb. F.F. $1:8\frac{1}{2}$.

Check rails and blocks were 75-lb. F.F. The greatest difficulty met with was to keep the gauge accurate. The great variety of material (at first 40-lb. and 45-lb. chairs were mixed up together) prevented the provision of the "Box" form of template. This is a template *through* which the sleeper is bored. It holds the auger perpendicular and is, of course, accurate. Sufficient templates of this kind could not be made to keep 20 augers employed, for each different kind of chair and sleeper. The method of laying by which one rail is laid first and then the other to gauge, was rejected as being far too slow. The method adopted was to make a board template, the under side of which was covered with metal. Through this the carpenters made punch centre marks for the guidance of the augers and marked the centre of the sleeper. It was not an accurate method as the auger was not held perpendicular, and so the spikes drove the chairs in or out. Another source of inaccuracy was the fact that the 45-lb. chairs are too big for the 73-lb. rail.

A great deal of re-gauging had to be done when the lines were finally packed up. The error was from "plus" $\frac{3}{8}$ in. to "minus" the same, the majority (especially with the jarrah wood) being on the tight side.

The average rate of laying completed track (including unloading) when all material fitted, was 5 lengths per hour. The maximum at railhead 57 lengths in 8 hours. The maximum when doubling, 88 lengths in 8 hours (a length is 30 ft. and there are 12 sleepers to a length of 73-lb. chaired road).

It was found:—(i.). That it was more economical to spike the chairs on to sleepers after spreading because two men can double with a "light" sleeper; three men cannot double with a loaded sleeper.

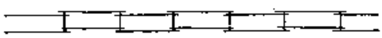
(ii.). That it took 12 men to lift a 30-ft. 73-lb. rail comfortably and handle it smartly. These men were made to work to a whistle.

(iii.). That it was more economical to carry material straight to its place than to make use of trollies. (Note, only five trollies were available, ballast trains were more often than not, loaded in the wrong order, there were no shunting facilities within reach, and the lead was never more than 650 yards).

(iv.). That it was best for spanner men to work in pairs, with one crowbar between three pairs, and for keymen to work in threes—1 hammer, 1 tommy, 1 crowbar.

Bridge Erection.—The overbridge at Azadpur, (4) on map, was entirely the work of the company. At (2) small girders were placed in position. These were only 12-ft. girders. At three (3), 10-ft. square trough girders were put in.

The construction of the overbridge at Azadpur consisted of a double 11-ft. roadway, carried on four Warren girders of 60-ft. span. The road transomes were 11-in.×5-in. **I** girders strengthened by 3-in.×3-in. angle iron. Triangular struts were bolted to the top of the road transomes and under the top flange for transverse stiffness; longitudinal stiffness being given by angle-iron bracing under the transomes. The floor is made of six rows of sleepers on edge, bolted to their ends so:—



These were then covered with kunker placed on 14-gauge C.I. sheeting.

Work was carried on intermittently on the cribs as material arrived. The first girder took 10 hours in erecting, and the last only four.

The main cribs were bolted right down the four corners and were constructed of new deodar sleepers. These were bored with a template and threaded on to the bolts from above. Owing to the number of intermediate sleepers (three sleepers touching each other) a good deal of adzing was necessary to get an even bearing. This spoils the sleepers for future use as such, but packing pieces were inadmissible. The crib building was in charge of Sergt. Butt, R.E.

Two 40-ft., 12-in. square, derricks were employed for lifting the girders. The main lifting tackle consisted of 5-in. rope, two quadruple blocks and a snatch block. The side guys were doubled 3-in. rope. The fore and back guys were compound, *i.e.* the portion attached to the derrick was a doubled piece of 4-in. To this was attached on the fore guy, a single and double tackle 3 in.; to the back, a double and treble tackle 3 in. The 4-in. was doubled to save cutting. The tackle was varied because it was all that was available. Tackle was put into the guys because the girder had to be lifted up the side of the crib with the derrick straight, and then put on to its bearings by leaning the derrick over. Holdfasts were made of sleepers sunk 6 ft. into the ground and were of the 2 : 1 type.

The whole strength of the company was employed for lifting, more for instruction than from necessity.

The method adopted was as follows :—The standards having been erected the derricks were allowed to rest against the embankment. The girders were then crowbared from their position parallel to the railway lines, to a position across them and as close as possible to the crib (see *Plate, Sketch* 1).

The derricks were next raised and the girder made to stand on the bottom chord. The girder having been "scotched" into its new position, the derricks were again moved closer. The girders were then lifted into position. The total lift was 24 ft., and when in position the bottom chord is 16 ft. 6 in. from rail level.

The only difficulties met with were :—

(i.). The appalling ignorance of the men. About 1 per cent. only had any knowledge of knotting, and all were frightened of a rope when loose and absolutely callous of holding the same when the weight was on it.

(ii.). With the first girder. Four cribs having been built to get the distance pieces in, No. 1 Girder had, of course, to be lifted from the outside. The derricks could not "lean" and had to be lifted with difficulty off cribs. Once got standing they were left so. So that the girder had to be got past two pairs of cribs and then between the derricks and the cribs (see *Plate, Sketch* 2).

(iii.). When the girder was not hanging quite plumb, it was found that if the top flange was allowed to take its bearing and the bottom chord then levered into its "clip," the top had a most disconcerting habit of coming off sideways, throwing the weight on to the tackle again. Experience showed that it was advisable to get the bottom chord home first and then lower on to the bearing.

(iv.). The age of the girders. They arrived in three pieces each and were bolted together at site in the ground. The bolts did not hold the top flange sideways and the consequence was that, when in position after lifting, the flange in every case exhibited a reverse curve. They straightened out, however, when the road transomes were put in. The girders, it is understood, have been on the scrap heap for 20 years. In their prime they carried broad-gauge engines.

The other two bridges were simple and were merely a case of 15 minutes man-handling in the case of the 12-ft. girders, and of four hours in the case of the troughs, which were much more awkward to handle.

Maintenance.—In the beginning of September the company took over the maintenance of the whole of No. 2 Section of the D.D.R. This arrangement proved unsatisfactory owing to civilian supervision, and on the 20th the portion Azadpur-Army Camp was taken over by the company, the remainder being handed over to civilian labour.

The rain at the end of September did a great deal of damage to the line, washing out the bank under the down line between Azadpur and Durbar.

The bund was finally breached on the 8th October and the up line was passed for passenger traffic on 13. 10. 11. The down line was ready for traffic from Azadpur to Durbar on 16. 10. 11. By the end of October the line was doubled between Army Camp and Durbar, and only one crossing remained to be put in in Durbar Yard. This work presented no points of special interest.

Reorganization.—To ensure efficient supervision, the company was now slightly reorganized, so that the organization for work became the same as the military organization. The company was divided into four sections, each under a havildar, and each section again was further divided into two or three squads, each under a naik. Each jemadar was placed in charge of two sections. The line similarly, was divided into four distinct sections, as follows :—

(1). Azadpur to Durbar (exclusive).
(2). Durbar Yard.
(3). Durbar to Army Camp (both exclusive).
(4). Army Camp Yard.

Each section (company) consisted of 35—40 men, and each section of the line contained about 400 lengths, *i.e.* approximately $2\frac{1}{2}$ miles.

The result of the above was that each N.C.O. always had the same men under him, both during work and on drill parade, and each was made to realize that the efficiency of the particular part of the line of which he was in charge depended entirely upon the efficiency and good work of his own section. Under these conditions, the work of the men steadily improved.

Maintenance work was continued throughout the Durbar period, without a hitch or accident of any kind. In fact a compliment was paid the company by the Traffic Department asking them to assist in regulating the traffic on Durbar day, and also on the days of the Review and Military Tournament, as the ordinary open-line coolie was not sufficiently to be depended upon.

The men took part officially in no parade during the Durbar, but owing to the kindness of General Cox and Sir John Hewitt seats were allotted to the company both in the Amphitheatre and at the Review.

The Native officers, however, were presented to H.I.M. the King-Emperor by the O.C. on the occasion of the presentation of all the N.O.'s in Delhi.

Dismantling.—During the first week in January practically all the civilian coolie labour was dismissed, the company took over the Cavalry Camp line as well for dismantling, and the O.C. was appointed temporarily as S.D.O., Azadpur.

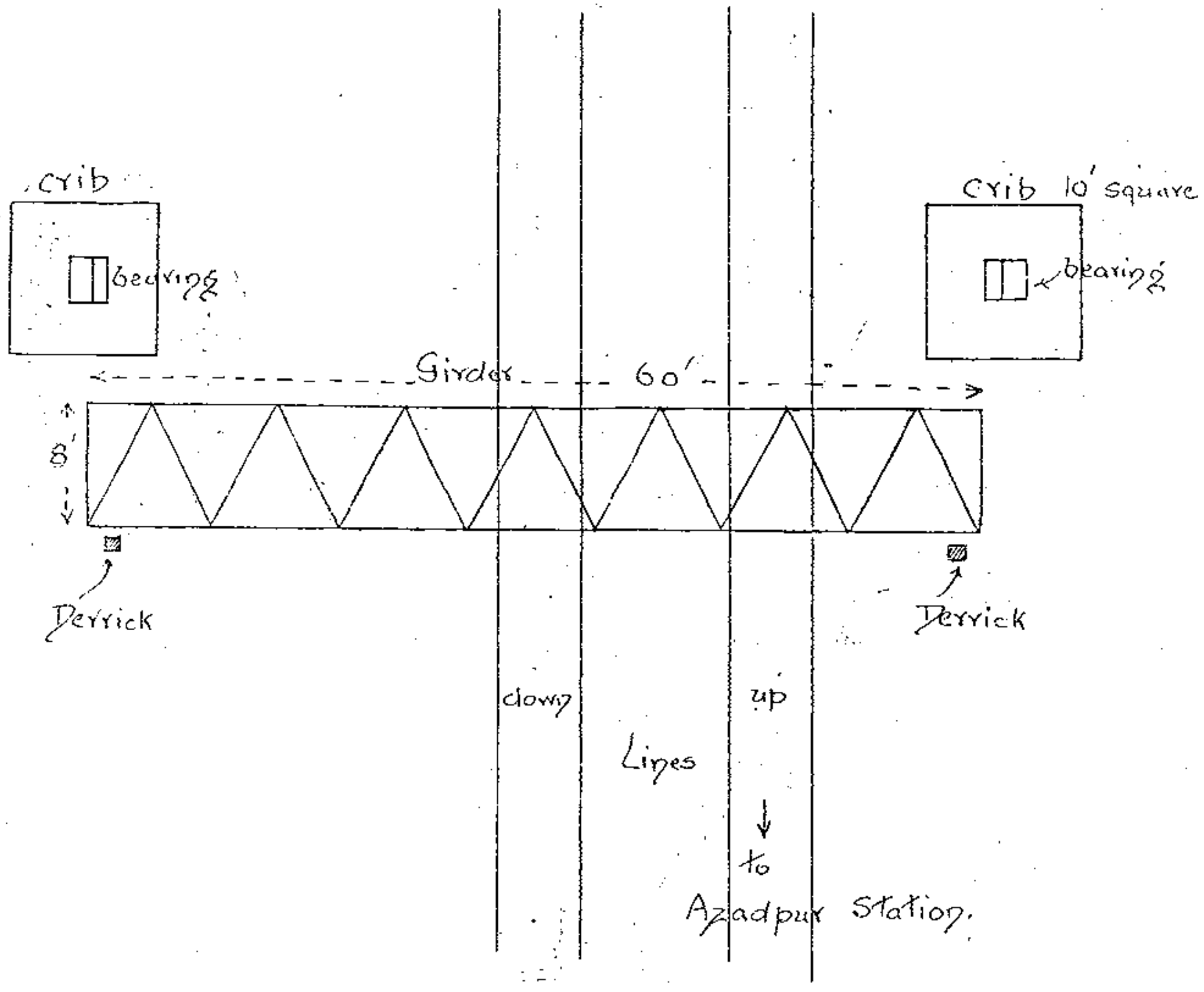
Within a fortnight all the station buildings, fencing, watering arrangements, and as much as possible of the lines to Army and Cavalry Camp had been pulled up, the material being placed close to the line remaining.

In dismantling the 12-ft. × 12-ft. × 4-ft. water tanks, which were placed on 20-ft.—25-ft. crib piers, three 30-ft. rails were used, and the tanks were pulled over on to these by tackle and slid down.

The remaining period was used to load material as wagons became available. The sidings were dismantled in Army Camp and Cavalry Camp but the work was greatly delayed owing to the scarcity of wagons and trucks.

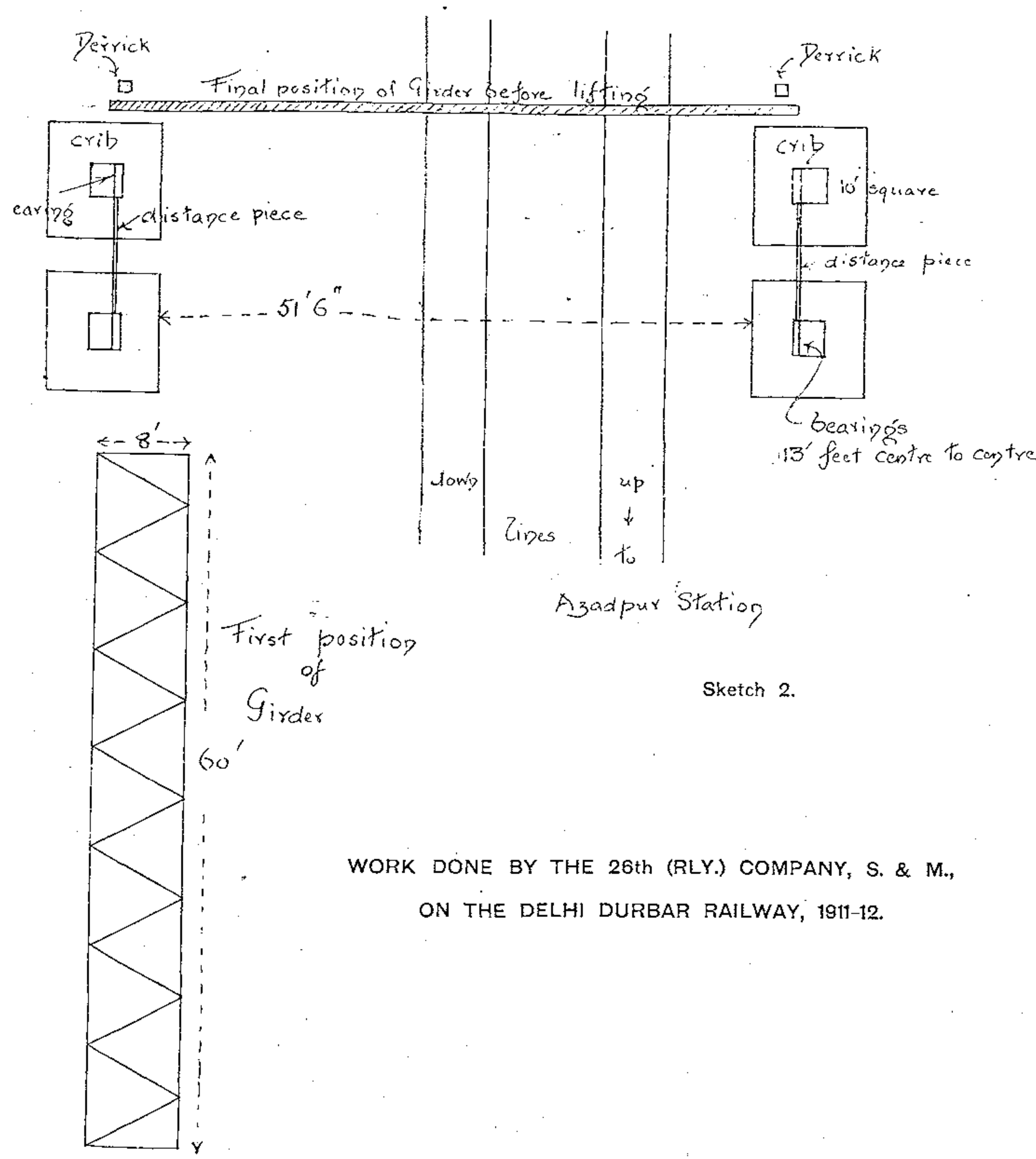
Miscellaneous.—During the latter period those men to whom furlough was due were allowed to go as furlough was a year overdue. Casual leave too, has been granted as much as possible, as practically no leave was granted previous to the Durbar.

Latterly a section at a time has been withdrawn altogether for a day, for instruction in knotting and lashing, and it was found that very few of the men knew anything at all about it, though the majority of the N.C.O.'s could be relied upon to tie the commoner knots.



Sketch 1.

Scale :—12 ft. to 1 in. throughout.



Sketch 2.

WORK DONE BY THE 26th (RLY.) COMPANY, S. & M., ON THE DELHI DURBAR RAILWAY, 1911-12.

THE EMPLOYMENT OF R.E. IN WOOD FIGHTING.

By CAPT. W. G. S. DOBBIE, R.E.

IN an article in the August, 1913, number of the *R.E. Journal* on the subject of operations in woods, an attempt was made to discuss the bearing of woods on the tactics of infantry and artillery. But very little was said about the work of the R.E. in connection with wood fighting. It seems to be a reasonable assumption that woods will be more important tactically in the future than in the past. Many factors contribute towards this end, notably the introduction of aircraft and the consequent necessity for troops to conceal themselves in woods, villages and other similar localities. In the August article the paramount importance was shown of training the infantry in peace time in this sort of fighting, as in many respects it differs from other kinds of fighting and imposes a very great strain on the nerves of those who are unaccustomed to it. It falls to the lot of the R.E. to help on the infantry over difficulties of terrain, and it therefore behoves us to give the question careful consideration, so that we may be able to find out and practise the best means by which we can do so. It is a subject which needs to be carefully studied, as the light of nature will not tell us what to do, and it is a subject which perhaps repays study more than most.

It is proposed to deal with the work of the R.E. first in attack and then in defence. And before we can settle the best manner in which the R.E. can help the infantry in the various phases of the action, it will be necessary to remind ourselves of the special characteristics of the particular phase that we are considering.

Attack against the Front Edge.—In this phase the action will be of much the same nature as in any other part of the battlefield, except that the attacking infantry will probably have a more distinct objective than usual, viz. the edge of the wood. The artillery of the attack will also be able, in most cases, to support the infantry with greater effect than usual, as the defence may not be able to bring much artillery fire against the ground in front of the wood. These remarks are, of course, very general, but the tendency will be for the attack to make ground to the front more quickly than usual. The work of the R.E. in this phase will be much the same as in any other attack, but the R.E. must be well up, and in considerable numbers, as they will be needed as soon as the front edge is carried. Not only a few men with cutting tools, such as very often accompany an infantry attack, but the bulk of the R.E. company that happens to be on the spot. In the event of the Brigadier (or the officer directing the attack) forgetting to send up the R.E., it will be the duty of the senior R.E. officer to remind him of the importance of the R.E. being well up during the attack. In the case of divisional headquarters, when orders for the attack of a wood are being got out, the C.R.E. should see that R.E. are detailed to accompany the attacking troops. It is difficult to lay down any definite proportion of R.E. to infantry in these circumstances, but it may be taken as a rough guide that the *absolute minimum* is one field company to a brigade or one section to a battalion.

Fight inside the Wood.—In the attack on a wood, history shows that the real danger to the attacking troops occurs, not during the advance against the edge of the wood, but after the edge has been gained and the troops penetrate inside the wood. The passage through an unknown wood always causes confusion, and the defenders have excellent opportunities of making vigorous counter-attacks with the bayonet, and of driving the attackers out of the wood again. Time after time has this occurred, and numerous instances of this phenomenon were cited in the August article. The effect of these counter-attacks has been out of all proportion to the numbers employed, for the simple reason that they come as a surprise. Here then is a matter in which the infantry need help, and it is up to the R.E. to provide it. Let us briefly review the situation. The attacking infantry have succeeded in gaining the edge, and although they may not have encountered very severe opposition, they are bound to be in considerable confusion. The artillery which has so ably helped on the attack can no longer assist, and the infantry feel that they are now left to their own resources. The enemy, who held the edge, has withdrawn into the interior of the wood. The trees prevent our troops knowing what forces of the enemy may still be lurking in the interior. The enemy knows his way about the wood, our troops do not. Everything in fact combines to make the men jumpy and to see dangers where none exist, and this is one of the reasons why the counter-attacks referred to above produce such surprising results. If the infantry could see some slight obstacle of breastwork between themselves and their invisible foe their nerves would be very much steadied. They cannot make it for themselves, as they carry very few cutting tools, and as they are busy reorganizing. It is here that the R.E. can help. Some slight breastwork should be made just inside the wood, *directly* the edge is captured. This breastwork need not be bullet proof, as the bayonet and not the firearm is the weapon for the interior of a wood. The breastwork need not be elaborate, so long as it provides a slight obstacle to the progress of a counter-attack. Its effect is intended to be moral rather than physical—and speed in its construction is of more value than an elaborate design. This is a thing that might well be practised with infantry in any station where government woods exist. The details must be adapted to suit the various kinds of wood. In some cases branches should be cut down to form a rough abattis. In others, trees should be felled. In the latter case should explosives be used or not? If so they must be carried by hand during the attack, perhaps in the form of ready-made necklaces. The tool carts with more explosive, or the pack animals, will have to be rushed up as soon as possible, as more explosive will have to be used during the passage through the wood. There are here innumerable little points that will have to be thought out, discussed, and actually tried, as the conclusions arrived at by experience are always much more valuable than those gained by theory.

The Fighting in the Wood.—The characteristics of the fighting in the wood are that the defenders will endeavour by numerous small counter-attacks to drive the enemy out again. There are many instances in history of attacking troops forcing their way almost to the far side of a wood, and then being counter-attacked and driven right back again. It seems to be very difficult to rally the troops if they are being driven back by a counter-attack, and anything that the R.E. can do to help to check the retirement will be of value. General Clery in his *Minor Tactics* points out how extremely important it is for troops working through a wood to keep some formed bodies, however small, at hand so as to check the counter-attacks. These small bodies will be the better able to carry out their functions if they are provided with some slight protection of the same kind as that mentioned above. It will fall to the lot of the R.E. to provide this protection and form little rallying points at different places in the wood, behind which the troops could rally in the event of their being pushed back by the enemy's counter-attack. It is not contemplated that these rallying points should be capable of an obstinate and protracted defence. For one thing it is not likely that their flanks could be secured, nor that the enemy could be prevented from working round the flank. But they are intended simply to gain sufficient time for the retiring infantry to pull themselves together preparatory to renewing the advance. The moral support of such works will be great if the advancing infantry know that close behind them there is some shelter however flimsy.

The best methods of preparing these rallying points will need to be carefully studied as well as their size. Probably this latter will not be very great, as there will rarely be much time in which to do the work, and they will be most effective if they are small and fairly numerous. If this is so the R.E. must be split up into several small bodies, so that they may be able to construct several of these posts at the same time.

Again, to refer to the lessons of history; all the records of wood fighting prove how very tenaciously a small force may hold on to the interior of a wood, and how very difficult it is for the attackers to clear the wood of the defenders. The latter, presumably, know their way about the wood better than the attackers, and will be able to turn this local knowledge to good account. In order then to occupy a wood, it will be necessary to make good each part systematically. For this purpose the defensive posts referred to above should prove most useful, and so their construction would be doubly justified, as they would, so to speak, be killing two birds with one stone.

Debouching from the Wood.—Very often the main defensive line will be behind a wood, especially in that part of the field where the defenders do not intend to take the offensive. It may therefore be necessary for the attackers to debouch from the wood for the attack of the main position. The French position about Elsasshausen at the Battle of Worth was an instance of this. Debouching from a wood under these circumstances is an extremely difficult operation, as generally all the advantages of artillery support will lie with the defenders. How best can the R.E. help here? In the first place, the far edge of the wood may be entangled and observation mines may be encountered at places where the attackers are likely to congregate. The discovery and removal of these will fall to the lot of the R.E. In this connection it must be remembered that if the enemy have placed one mine in a certain locality, they have probably placed several, and a thorough search will have to be made for them before the infantry attempt to mass near the edge. The infantry will be in considerable confusion after their passage of the wood, and before the advance is continued it will be absolutely necessary to reorganize. It is suggested that this reorganization take place at a little distance from the edge, inside the wood, and that while it is going on the R.E. should be searching for the mines, and removing the entanglements so far as they can.

In order that the infantry may debouch from the wood, it will generally be necessary for them to be supported by artillery fire. As it may not be possible for guns to afford support from positions behind the wood, some guns may have to be run up to the edge of the wood. The Germans did this at Worth and it was the fire of these guns that enabled the German infantry to debouch from the Elsasshausen Copse and make their attack on Elsasshausen village. The R.E. may be required to make the road for the guns through the wood, and to prepare gun pits for the guns, defiladed or blinded as far as possible from the hostile gun positions.

In defence the R.E. will be equally fully employed, though their work will naturally be on rather different lines.

Woods may be held defensively for a variety of reasons, viz.:—

(*a*). As an advanced post to break up the enemy's attack—as the French held the wood near La Folie at Gravelotte, and as the Austrians held the Swiepwald at Sadowa.

(*b*). As part of the main defensive line.

(*c*). As a pivot on which to hinge an offensive movement.

In the last case, the object of the defenders will be more to deny the wood to the enemy, with a view to protecting the flank of the offensive movement, than to develop much fire from the edge—though a certain amount of fire to the flank will no doubt be aimed at.

The reason for which it is decided to hold a wood will affect the manner in which the task should be carried out, and so also the work of the R.E. But in most cases the question of the advisability of holding the front edge will come forward, and will have to be decided. As this point was discussed at some length in the August article it is not proposed to enter into the *pros* and *cons* here. But presuming that it has been decided to hold the front edge, in what way can the R.E. be best employed before the action commences? There are two methods of keeping the enemy from gaining or maintaining himself in the edge of the wood. The first is by posting one's men at the edge with the object of fighting there, and holding out then to the end. In this case the defenders are liable to be exposed to heavy artillery fire without the support of their own artillery. Consequently they will need all the protection that the resources of the Engineer can give them. Good overhead cover will have to be provided to guard against shrapnel, and the R.E. will probably be called upon to make it. Again, as high-explosive shell will probably be used against the defence works, the trenches must be so designed as to localize the burst of one of these shell as much as possible. If the trench is constructed exactly at the edge of the wood, traverses will not be easy to make, and the Engineer will be called upon to advise and assist in this matter. Further, if time permits, the desirability of making bombproofs will have to be considered, and, if necessary, a suitable form of bombproof evolved. Again, field or machine guns may be used for close defence and for flanking the front of the wood. They will have to be dug in and given very substantial protection on their outer flank. The Engineers may be required to see to this. In fact, when the front edge is being held in strength, the Engineers will have their hands full.

The second method of holding the front edge of the wood is, to use an Irish expression, not to hold it at all in strength, but keep the bulk of the defenders handy a short distance inside the wood, ready to counter-attack the enemy with the bayonet as soon as he has gained the edge. This was the method adopted with such signal success by the 3rd Zouaves at the Battle of Worth. Generally speaking this method is the best, as the defending troops are demobilized far less than if they were all tied down to defence works at the edge. A small proportion will have to line the edge, more with the object of delaying the attack and causing some confusion than with seriously disputing the advance to the edge. In this case also the R.E. can be of much assistance to the infantry. As the essence of the defence in this case is the counter-attack, the R.E. should be employed in such a manner as to assist the counter-attack. This can be best done by improving the communications through the wood so that the defenders can move rapidly and easily form one point to another. Small breastworks would also be useful in various places, just sufficient to check the advancing enemy, and give the defenders an opportunity of making a successful counter-attack. The troops lining the edge will also have to be protected as well as possible, and communications to the rear will have to be made by which they can withdraw when the time comes to do so.

The question of the desirability of holding a line some distance in front of the wood was discussed in the August article, and need not be referred to again here, except to point out that the R.E. will have to assist in the preparation of covered communications between the edge of the wood and the trenches.

A line behind a wood affords many advantages from a defence point of view. It is usually so very strong that the numbers of the defenders may be very greatly reduced and they will depend on fire action rather than shock. The strength of such a position lies in the enormous difficulty troops experience in debouching from a wood under fire, and in the fact that usually the defence is superior to the attack in artillery fire at this point. The difficulty experienced by the Prussians in debouching from the woods of Maslowed and Sadowa in 1866 is a case in point. The Engineers can help the defence best by making these difficulties greater than ever, and entangling certain portions of the edge of the wood, thereby restricting the length from which the enemy can debouch. Arrangements must be made that the unentangled portions of the edge are under very effective rifle fire, which should be cross-fire whenever possible. Land mines also, suitably placed, would be of much service to the defence. In the trenches themselves head cover will have to be provided, though "overhead" cover may not be necessary.

As the number of rifles of the defence will be small, each rifle must be able to develop the fullest amount of fire, and the head cover will have to be designed accordingly. The R.E. will, at any rate, have to advise in this matter, while the bulk of their work will be at the edge of the wood.

As the difficulties of debouching from the wood by day are so great, the enemy may try to emerge by night. This being so, a system of flares, alarms, obstacles, etc., will have to be arranged beforehand. This provides more work for the R.E., whose hands will probably be more than full.

The foregoing remarks are intended to show that the R.E. are in a position to help the infantry enormously in wood fighting, and that there will be no question of their not having enough work to keep them fully employed. As we are certain to have a great deal of wood fighting in the event of service in a civilized country, the importance of specially studying the question is apparent. In some stations, no doubt, the work can be actually practised by the R.E. companies in conjunction with infantry. In others this is not so easy, but much good can be done by the use of outdoor exercises for officers and N.C.O.'s, and by discussing on the ground the small details of the work that would be carried out.

THE SIPHON AS AN AID TO WATER SUPPLY.

By CAPT. E. W. S. MAHON, R.E.

As military text books contain no mention of siphons as an aid to water supply, the following short description of one, which was successfully installed in Sierra Leone recently, may prove of interest.

The chief advantages claimed for this method of water delivery are that the action is automatic, the labour and expense of pumping is avoided, the discharge can be easily controlled, and, when once in proper working order, a few minutes' attention daily is all that is necessary to maintain the flow from the siphon. All the pipe can be laid above ground, or sufficiently near the surface to make it easily accessible for repairs.

Siphons have I believe frequently been used in connection with reservoirs which are so situated as to provide a gravitation supply, and it would appear to be an advantageous system to follow for this purpose, as all possibility of failure of the dam (should one exist) or of draining the reservoir, owing to leakage in connection with the outlet, is absolutely precluded. Since there is undoubtedly a limit to the size of pipe which can be made perfectly air-tight (the first essential for a siphon), the number of siphons to serve a reservoir might have to be multiplied to ensure delivery of the requisite supply; this would, however, be no disadvantage since it would increase the facilities for controlling the discharge.

Siphons can be used for draining areas and excavations, or for extracting water from underground supplies; for these purposes they can of course only be employed in certain localities where water is met with comparatively near the surface, and where the delivery pipe from the siphon can be graded at a slope, which will enable the end of it to be taken low enough to induce a sufficient discharge within a reasonable distance.

In all cases the delivery end of the siphon should be below the lowest level to which it is desired to drain the reservoir or area (which is limited by a depth of 27 ft. or 28 ft. below the highest point of the siphon). The delivery pipe should be graded downwards from the highest point at a uniform or a gradually increasing slope throughout; there should at any rate be no "concave" bends in the grade unless absolutely unavoidable, as they favour the formation of air pockets; and any upward grading is fatal to the proper working of a siphon unless provision is made for extracting air at the top of the bend. The outlet at the end should be controlled by a valve or tap of smaller bore than the pipe, to obviate any possibility of air admission at this point when discharging full bore.

Every joint must of necessity be made perfectly air-tight, but since air is contained in greater or less quantities in the water itself, provision must be made for periodically extracting any air which may accumulate at the highest point in the siphon, without interrupting its flow. This can be best effected on the air-lock principle, by adding an air-collecting chamber at the highest point of the system, controlled by valves at both ends, into which water can be poured to replace any accumulated air. This arrangement also provides an inlet for filling the siphon.

The siphon fitted up at Sierra Leone, is for use in connection with the water supply to Tower Hill Barracks, which usually falls below normal requirements towards the end of the dry season in April and May. With a view to supplementing the supply, trial borings were made in the catchment area containing the streams which provide it, and water was found at a depth of about 12 ft. below the surface in such quantities as to indicate the existence of an extensive underground reservoir. The water-bearing stratum consisting of fine sand, and gravel 6 in. to 1 ft. thick was found to be held between an upper stratum of laterite clay about 10 ft. thick and a lower stratum of syenite; the water in it was borne under pressure sufficient to raise it to within about a couple of feet of the surface as soon as the clay stratum was pierced.

Two boreholes were sunk within 40 ft. of each other and lined with 4-in. C.I. pipes; a 2-in. G.I. pipe was inserted in each and connected up to form the double siphon as shown in *Plate* I. The delivery pipe was carried down the valley a distance of 530 ft. and closed with a $1\frac{1}{2}$-in. tap, discharging into a funnel screwed in the top of the 4-in. C.I. pipe which carries the main supply from the Catchment Area to Tower Hill.

Plate II. shows the grading of the delivery pipe and also of the 4-in. main. The point at which the connection was made was selected both with a view to the head necessary to induce the discharge required, and also because the steep change of grade in the 4-in. pipe enabled a junction to be made there without affecting the flow of the main supply within it.

The point of discharge is 25·3 ft. below the level of the highest point of the system at the junction of the two branches; 13 ft. below the bottom of the siphon pipe in the boreholes; and about 22 ft. below the normal level of water in the boreholes during the driest season of the year. The head at the point of discharge would appear to be the number of feet that point is below the level of water in the borehole, added to the head of upward pressure there (which increases as the water level is lowered).

At the end of the dry season with 10 ft. water normally in the boreholes, a discharge of 20 gallons a minute, or 28,800 gallons a day, was obtainable by lowering it $6\frac{1}{3}$ ft. or to 15·7 ft. above the level of the point of discharge.

In the wet season the level of water was a foot higher in the boreholes, and a discharge of 24 gallons a minute, or 34,560 gallons a day, was obtainable with a lowering of $6\frac{1}{4}$ ft. in the water level to $16\frac{3}{4}$ ft. above the point of discharge.

The maximum increase required for water-supply purposes at Tower Hill at the end of the dry season is, under present conditions, 10,000 gallons a day, so that the supply obtainable through the siphon is more than ample; still, as there is always the likelihood of increasing consumption in the future, it would be an advantage to replace the boreholes by a well; in addition to the much larger yield which would thereby be obtainable the possibility of stoppage of the siphons through silting up of the boreholes would be avoided. The system of boreholes was resorted to when the work was taken in hand, because there were no pumping or well-sinking appliances available in Sierra Leone, and the extra water was urgently required.

The joints of the 2-in. G.I. pipe were screwed in with hemp and red oxide paint, mixed in the following proportions:—2 lbs. red oxide, $\frac{1}{4}$ lb. driers, $\frac{1}{2}$ pint boiled oil, $\frac{1}{4}$ pint turps; they were also well caulked and painted on the outside; by this means all the joints were made absolutely air-tight.

The arrangement for filling the siphon and extracting air is shown on Plan A, the instructions explain the working. The hand pump was added to one branch of the siphon for convenience, but should preferably be separate, and instead of pumping direct into the air lock, the water could be raised (by an automatic pump if desired) to an elevated tank and piped to deliver to the air lock through a tap; this would in any case be the best arrangement where more than one siphon is involved.

I found that the force of the flow of discharge created a vacuum in the air lock, and that the amount of the vacuum increased with the rate of delivery from the siphon; water was displaced for a length of 14 ft. in the 2-in. pipe while the siphon was delivering at the rate of 20 gallons a minute, and for 17 ft. 6 in. when the rate was 24 gallons a minute. The formation of this vacuum did not appear to affect the working of the siphon in any way, as the rate of delivery remained constant whether the air lock was open to the siphon or not.

I also found that an apparent vacuum of about 2 ft. 8 in. of the 2-in. pipe remained in the air lock when the delivery end of the siphon was closed, the reason of this is not obvious, and I regret I had not time to investigate it thoroughly; could it be due to the artesian nature of the supply affecting the head of pressure at the foot of the siphon in the borehole?

It is hoped that a consideration of the successful results achieved by this siphon in Sierra Leone may be of assistance when other water supply and drainage schemes are in course of preparation, as not only is a siphon more easily and cheaply installed than any pumping system, but the cost of working and upkeep should be very small in comparison, which of course is greatly in its favour.

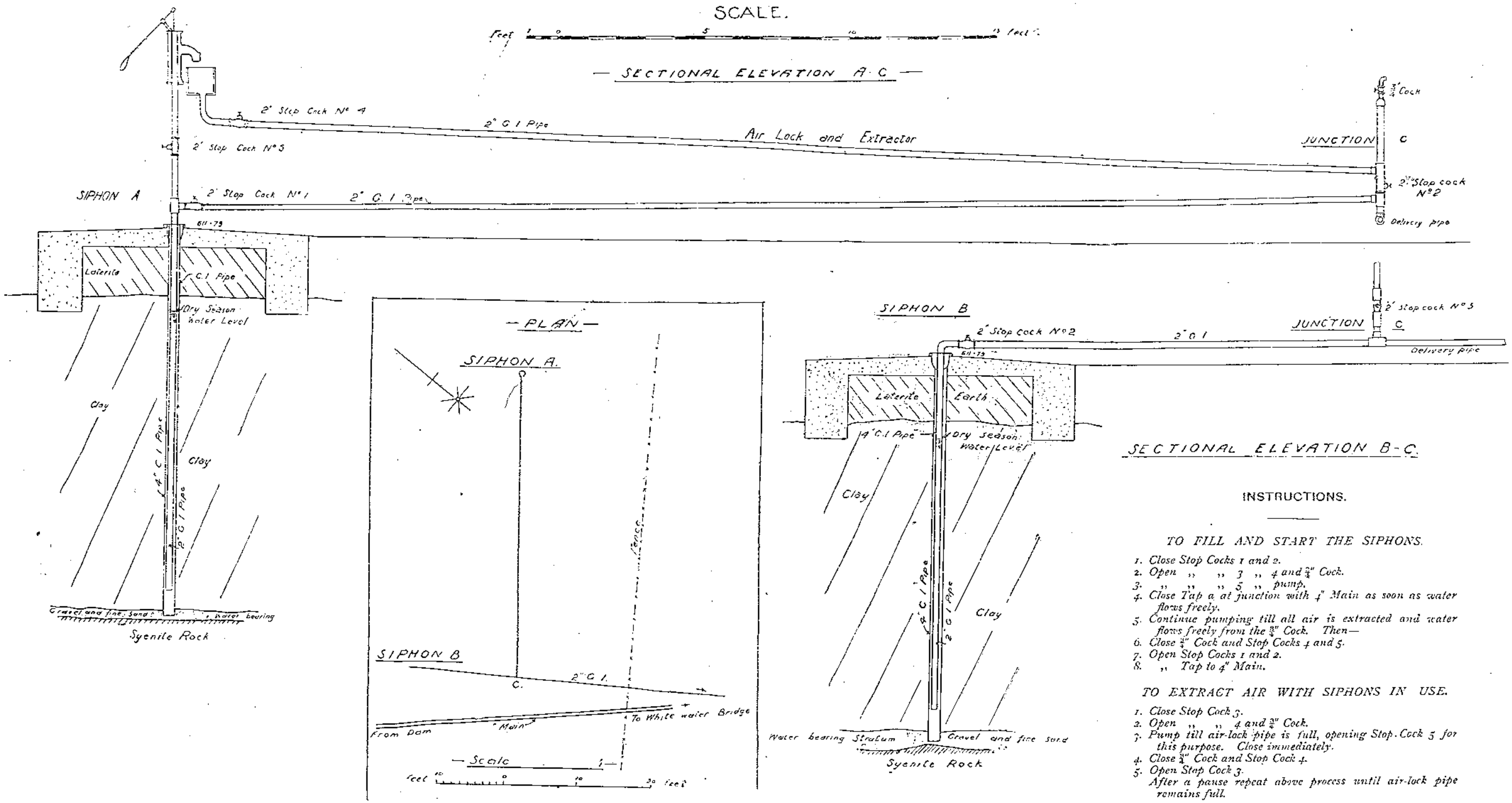
THE SIPHON AS AN AID TO WATER SUPPLY.

PLATE I.

SIERRA LEONE.

KORTRIGHT CATCHMENT WATER SUPPLY.

DETAILS OF SIPHONS AND AIR LOCK.



INSTRUCTIONS.

TO FILL AND START THE SIPHONS.

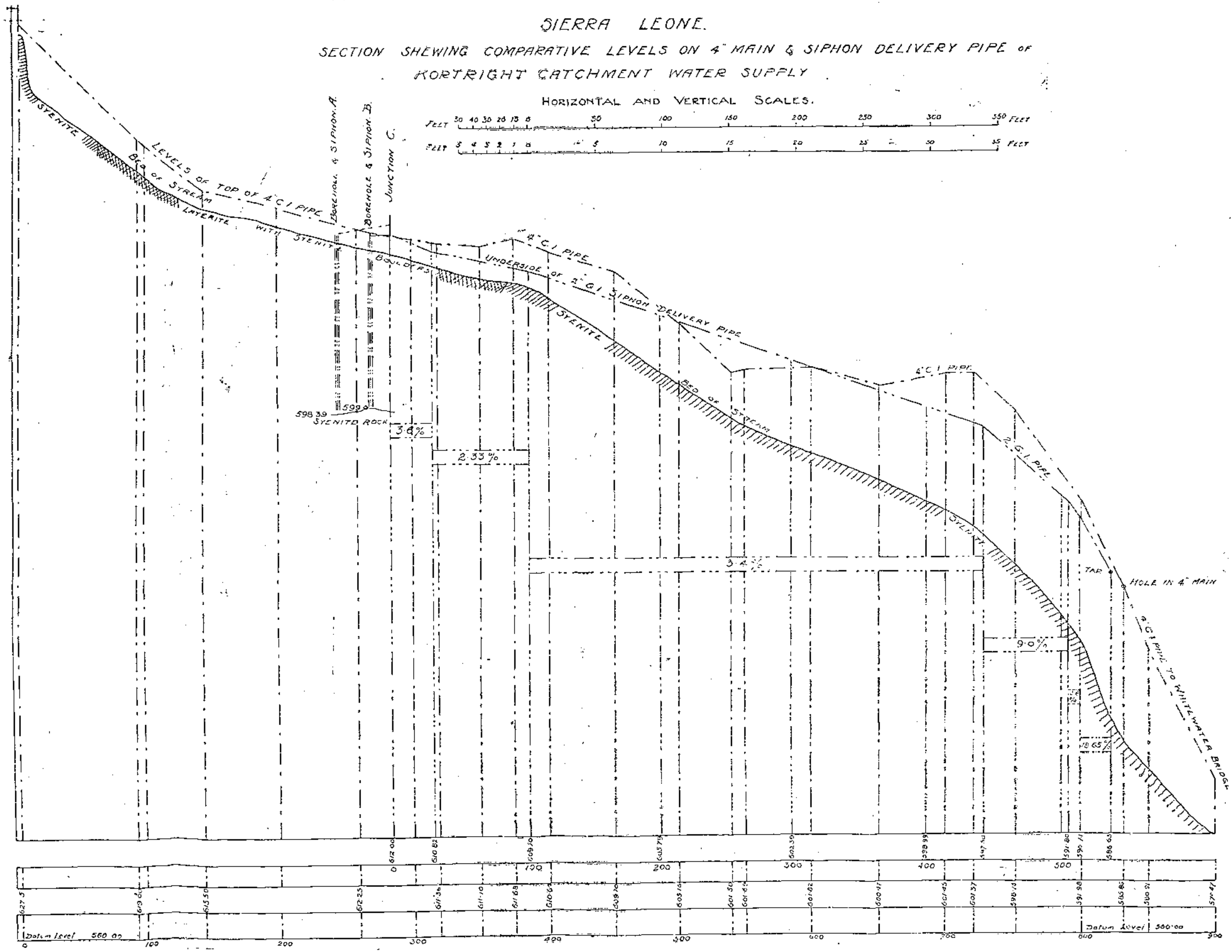
1. *Close Stop Cocks 1 and 2.*
2. *Open ,, ,, 3 ,, 4 and 3/4" Cock.*
3. *,, ,, ,, 5 ,, pump.*
4. *Close Tap a at junction with 4" Main as soon as water flows freely.*
5. *Continue pumping till all air is extracted and water flows freely from the 3/4" Cock. Then—*
6. *Close 3/4" Cock and Stop Cocks 4 and 5.*
7. *Open Stop Cocks 1 and 2.*
8. *,, Tap to 4" Main.*

TO EXTRACT AIR WITH SIPHONS IN USE.

1. *Close Stop Cock 3.*
2. *Open ,, ,, 4 and 3/4" Cock.*
3. *Pump till air-lock pipe is full, opening Stop Cock 5 for this purpose. Close immediately.*
4. *Close 3/4" Cock and Stop Cock 4.*
5. *Open Stop Cock 3.*
   After a pause repeat above process until air-lock pipe remains full.

SIERRA LEONE.

SECTION SHEWING COMPARATIVE LEVELS ON 4" MAIN & SIPHON DELIVERY PIPE OF KORTRIGHT CATCHMENT WATER SUPPLY.



CONSTRUCTION OF AN OBSERVATORY FOR ARTILLERY RANGES, SALISBURY PLAIN.

By LIEUT. E. WOODHOUSE, R.E., 57th (Field) Co., R.E.

THE observatory shown on the attached plates and photographs was constructed by the 57th (Field) Company in April, 1913, as a part of the annual fieldworks course, and is intended for observation of fire on the Larkhill Artillery Range.

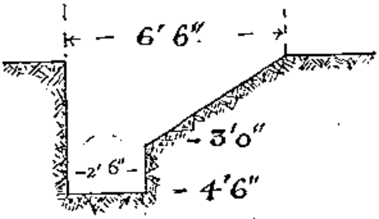
As there is a possibility of its being replaced in the future by a permanent steel structure, it was so designed as to leave the timber fit for subsequent use as far as possible. Mortices were therefore avoided in the joints, which are made with bolts and nails. At the same time, as the site on which it stands is very exposed, it has been solidly constructed throughout.

The constructional details are shown in *Plates* I. and II. The four sides are all alike with the exception of one diagonal in the top panel but one, which is specially constructed to allow access to the lower platform. Each of the four sides was put together and bolted up while lying on the ground at Bulford; each separate piece of timber was then marked to identify it for re-erection, prior to dismantling. The holes for the bolts were bored right through the several thicknesses of timber at the joints at one operation, with a view to ease in re-erection.

METHOD OF ERECTION ADOPTED.

The two legs "C" and "D" with the various members connecting them and the raking struts joining them to the ends of their own 26-ft. sills were put together on the ground and permanently bolted and nailed together (*Photos* 1 and 2). The four scarf joints in the legs were temporarily strengthened for erection, by 8-ft. lengths of 9-in. × 3-in. plank bolted on outside with ¾-in. bolts (*Photo* 2).

While the construction of this first frame was in progress a trench 27 ft. long × 4 ft. 6 in. deep × 2 ft. 6 in. wide was dug close to the sill of the frame, and the side of the trench towards the frame was sloped off as under.



Cross Section of Trench.

Four or five short lengths of timber were laid transversely in the bottom of the trench, and these were levelled through. The frame was built on lengths of 9-in. × 9-in. timber (portions of the remaining two legs) which had been packed up to the same plane in order to obviate any possibility of its being made "on the twist." The bolts for connecting the two legs of this frame with the horizontals leading to legs "A" and "B" respectively, had to be put in with their heads inside the legs as their tails would have fouled the ends of the inside diagonal members. They were therefore driven into legs "C" and "D" before this frame was put together. Some of these bolts were made use of to attach the temporary strengthening pieces for the four scarfed leg joints (*Photo* 2).

When the trench and frame were completed the latter was carried forward till the sill was over the trench. The portion of the frame to be buried was then tarred. It may be mentioned here that all joints in the structure were put together with a coat of tar between the surfaces.

While the above work was in progress a party had been employed in stretching and examining all ropes to be used in raising the frame and in preparing tackle and picket anchorages.

Method of raising Frame and Description of Tackle.—The frame was raised into an inclined position by two derricks, one on each side of it, and then was hauled into an upright position by a winch on a head guy. When tested for plumb, it was found to be leaning slightly to one side, the top being 2 in. away from the vertical. This was corrected by keeping a strain on one side guy, while the lower end of the sill was levered up. A bight of double 3-in. rope had been left in each end of the trench before the frame was raised, and a 16-ft. section of one of the remaining legs was applied to this rope as a lever.

The bottom sections of legs "A" and "B," each 20 ft. long, 9 in. × 9 in., were used as derricks. To obtain as much lift as possible from them they were erected with their lower ends 28 ft. from the sill of the frame. The derrick falls lifted the frame at a point immediately above the top scarfed joints of the legs. Before lifting, the strength of these joints was tested by levering them up with handspikes; they were found to deflect $\frac{5}{8}$ in. before the head of the frame lifted from the supports on which it was resting. The derricks might have lifted the frame at a point nearer the sill, but it was feared that the scarfed joints would suffer if this was done.

With a view to further increasing the lift obtainable from the derricks, the standing ends of their falls were not made fast to the top blocks in the usual way but to the slings from which these hung, thus enabling the tackle to be hauled up till the top and bottom blocks were actually in contact with one another. In addition to this, the movable blocks of the derrick tackles were not made fast to the legs of frame, but were lashed as close as possible to a beam made of three 12-ft. lengths of 6 in. × 2 in. on edge (afterwards used in decking of platforms) bolted and nailed together. This beam was passed under the legs, and was prevented from slipping towards the derricks by the projecting tails of the bolts in the scarfed joints of the legs.

This arrangement also ensured that the frame would leave the derrick tackles behind without difficulty as soon as the head guy took the weight.

The derricks were heeled inwards towards the frame and were not provided with fore guys. There was no risk of their falling outwards when relieved of their load as the above-mentioned beam on which the frame had been resting was by this time close to the heads of the derricks, and held them together.

List of Derrick Tackle, etc. (each derrick had to lift approximately 12 cwt.).

Falls	2-in. white rope.
Back guys	3-in. tarred single.
Side	3-in. tarred single.
	(In one case 2-in. white double).

Two double $2\frac{1}{2}$-in. blocks used for falls.
Picket holdfasts used for guys.

Photo 1 shows frame when raised as far as possible by the derricks. While being thus raised the sill of the frame was allowed to slide down boards against the back of the trench. The frame was then raised to an upright position by a head guy. A 1-ton winch borrowed from a neighbouring pumping station and anchored to two picket holdfasts was used to haul in this guy with a tackle of $1\frac{1}{2}$-in. wire rope, of which there was 300 ft. on the drum of the winch. As the slope of the ground rendered it possible to place the winch some 4 ft. or 5 ft. higher than the top of the foundation trench, a better angle was obtained for the back guy.

Two single 3-in. blocks were used on the tackle which was attached to the head of the frame by a long sling of four parts of 3-in. tarred rope. The stress in the back guy, obtained graphically, was 33 cwt. when the weight was taken off the derricks. This was borne by three parts of $1\frac{1}{2}$-in. wire rope in the tackle and four parts of 3-in. tarred rope in the sling. The fixed block of the guy tackle was fastened to a 3 : 2 : 1 holdfast of 5-ft. pickets. The actual work of raising the frame with the winch was done by two men.

At the moment when the frame left the derrick the thrust in the legs, obtained graphically, was 46 cwt. As the scarfed joints had to be made short through lack of material, they were temporarily strengthened as previously described. In order to lessen the deflection of the frame through its own weight and the above thrust, a light strain was kept on the top scarfed joints by a single 3-in. rope led to a small winch. This rope and also the head guy are shown in *Photo 2*.

ERECTION OF REMAINING THREE FACES OF STRUCTURE.

As soon as the first frame had been raised to a vertical position, the excavation of the remaining foundation trenches was proceeded with. To avoid widening the ends of the trenches for the purpose of driving the 17-in. bolts connecting the lower ends of the short raking struts with the ends of the sills, the latter were made in two pieces, with joints about the centre of their length. The raking struts were bolted up to the two half sills on the ground and then lowered into the trenches, the only bolts having to be driven below ground being those for the sill joints which were short (8 in.) and those connecting the sills to the legs which were easily handled in the trenches already dug.

The lower sections of legs "A" and "B," 20 ft. long, were built up into a frame complete with raking struts, sills and lowest panel of cross-bracing. When its foundation trench was ready this frame was easily upended in it by means of head ropes. A little manipulation with levers and slings served to bring it into a correct position with relation to the frame already in place, and then the lowest panel of cross-bracing between legs "D" and "A," and "C" and "B" was fitted into place. When this had been accomplished and the legs checked over with a plumb-bob the foundations were filled in, the chalk being well rammed as it was returned.

The following method was employed to raise the remaining two 16-ft. sections of legs "A" and "B.":—Two frames were made, each consisting of a pair of 16-ft. lengths of 6-in. × 3-in. timber bolted together, with 9-in. distance pieces between. The pulley of a $2\frac{1}{2}$-in. single block was housed in the distance piece at one end of each frame, and was free to revolve on a $\frac{3}{4}$-in. bolt passing through both the distance piece and the cheeks of the frame. The frames were attached to the heads of legs "C" and "D" by a single $\frac{3}{4}$-in. bolt, about which they were free to revolve through a small arc, and were used as crane jibs to lift the sections of legs "A" and "B" into place. The ends remote from the pulley were each anchored to the lower part of the main frame by a $2\frac{1}{2}$-in. rope. A single 2-in. white rope was rove through the pulley at the end of the jib, a snatch block at the head of the leg and a snatch block lower down the frame, whence it was led away to the warping drum of one of the borrowed winches. The pivot bolt of the jib was 9 ft. from the pulley and, as the legs of the structure are 8 ft. apart centre to centre, it was possible, by raising the jib above the horizontal, to swing the middle and top sections of legs "A" and "B" into place without difficulty.

Failing some contrivance of this sort it would have been difficult to erect these legs, as each section weighed about 300 lbs., and had to be manœuvred into its exact position while the scarf joints were bolted up. By the use of the winch two men were able to do this to a nicety. These cranes were also of assistance in raising other parts of the structure into place. They are clearly shown in *Photos* 1 and 2 and in *Photo* 3 one of them is shown lifting the top section of leg "B."

After the bottom sections of legs "A" and "B" had been brought into their proper positions with reference to legs "C" and "D," no difficulty was experienced in erecting the remainder of the structure, as all the members were found to fit together well with bolt holes in register. Some little discrimination was required in deciding which of the bolts connecting diagonals with horizontals should be driven from the inside, and which from the outside of the structure, as these had to be put in before all the timbers they connected were in place.

Two movable stagings were constructed for the use of the erecting party. These consisted of 9-in. × 2-in. planks on edge, 20 ft. long, clamped to the legs by "U" bolts of $1\frac{1}{2}$-in. × $\frac{3}{4}$-in. half round iron, screwed $\frac{3}{4}$ in. at the ends. One of these planks was clamped to each pair of legs and served both to hold them in place till the cross-bracing was fixed and to support planks for the erecting party to stand on. The 9-in. × 2-in. planks were afterwards used as decking for the top platform. These stagings are clearly shown in *Photo* 3.

With the exception of the four strengthening pieces for leg scarfs in the frame first erected and the crane jibs described above, all timber used for temporary purposes during erection was afterwards used up in the structure. An extra 20-ft. ladder was taken out but was very little used and could have been dispensed with. The crane jibs could have been dismantled and used for diagonals to top panel but were of some service after the top panel was completed.

Photo 4 shows the completed structure.

Detail of Man-Hours Worked.

The number of man-hours worked on the structure at Bulford was 618. Of these, 106 were worked by smiths making and shortening bolts, and making other iron work. 156 were worked by fitters, running down threads on bolts purchased or drawn from store, none of which were screwed far enough down, and screwing bolts made by smiths. The remainder, 356 man-hours, were worked by carpenters on the structure itself and by men assisting them.

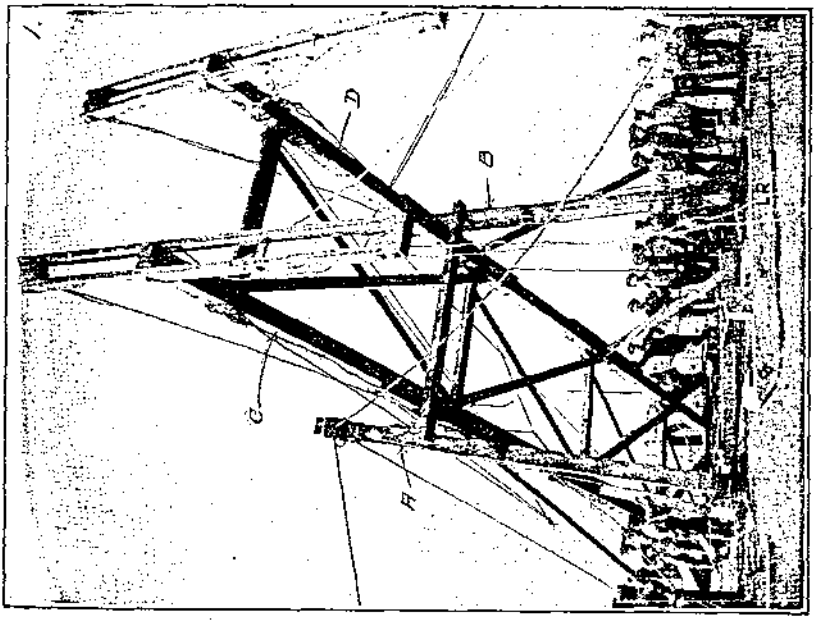
Two sergeants and 30 men were employed on the erection of the structure, which occupied five days. The number of man-hours worked, exclusive of the two sergeants superintending, was 988, of which 400 were worked by carpenters.

CONCLUSION.

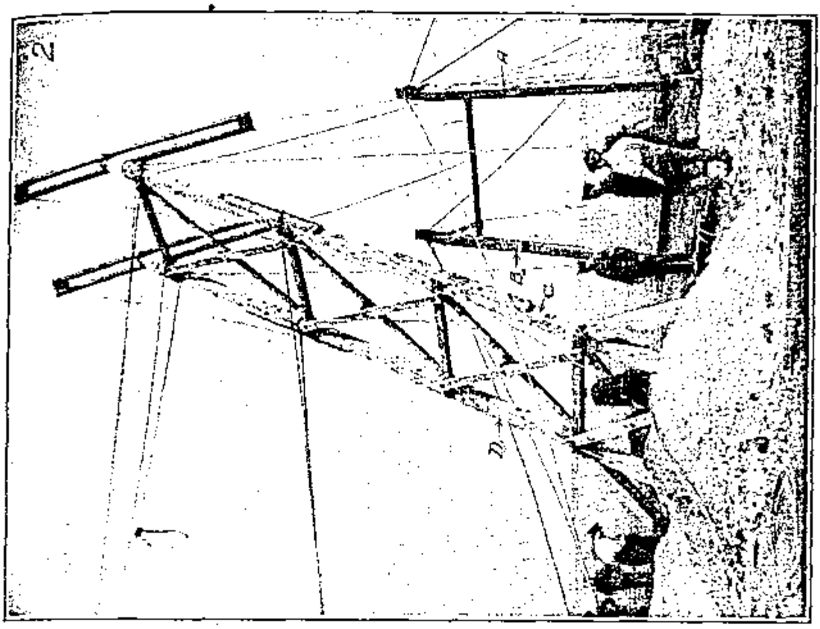
The earlier part of the erection was partly delayed by the excavation, which totalled 1,512 f.c. and was concentrated in a small space, so that the men employed were inclined to hamper one another. Shallower foundations would probably have sufficed, but it must be remembered that the structure is in a very exposed situation. On the last two days, work was much hampered by a very high wind accompanied by much rain.

If the structure had been built on the ground as two frames, instead of the second frame being put together piece by piece in the air the work would have been expedited, but it was feared that there would have been considerable difficulty in getting the second frame into register with the first after raising, in view of the fact that they each weighed about 46 cwt. Probably the best way of doing this would have been to raise the second frame with a derrick, but as a matter of fact there was no spar available in store for a derrick of the necessary height and strength.

CONSTRUCTION OF AN OBSERVATORY FOR ARTILLERY RANGES.

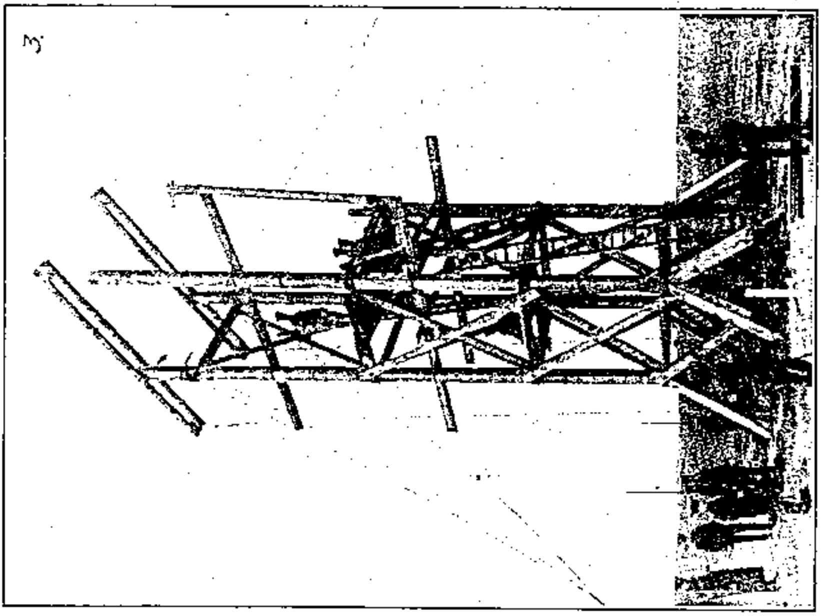


Position of frame raised by derricks.



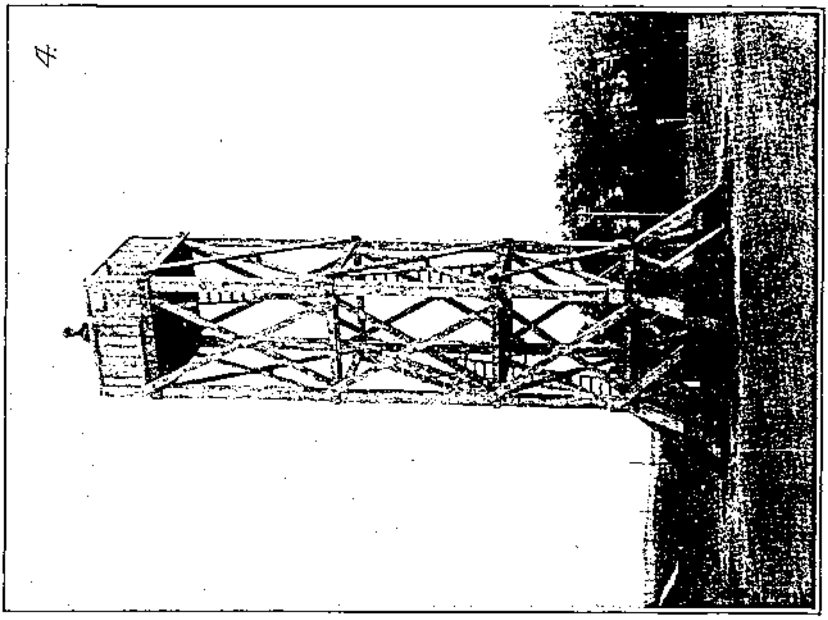
Frame being raised by guys.

CONSTRUCTION OF AN OBSERVATORY FOR ARTILLERY RANGES.



3.

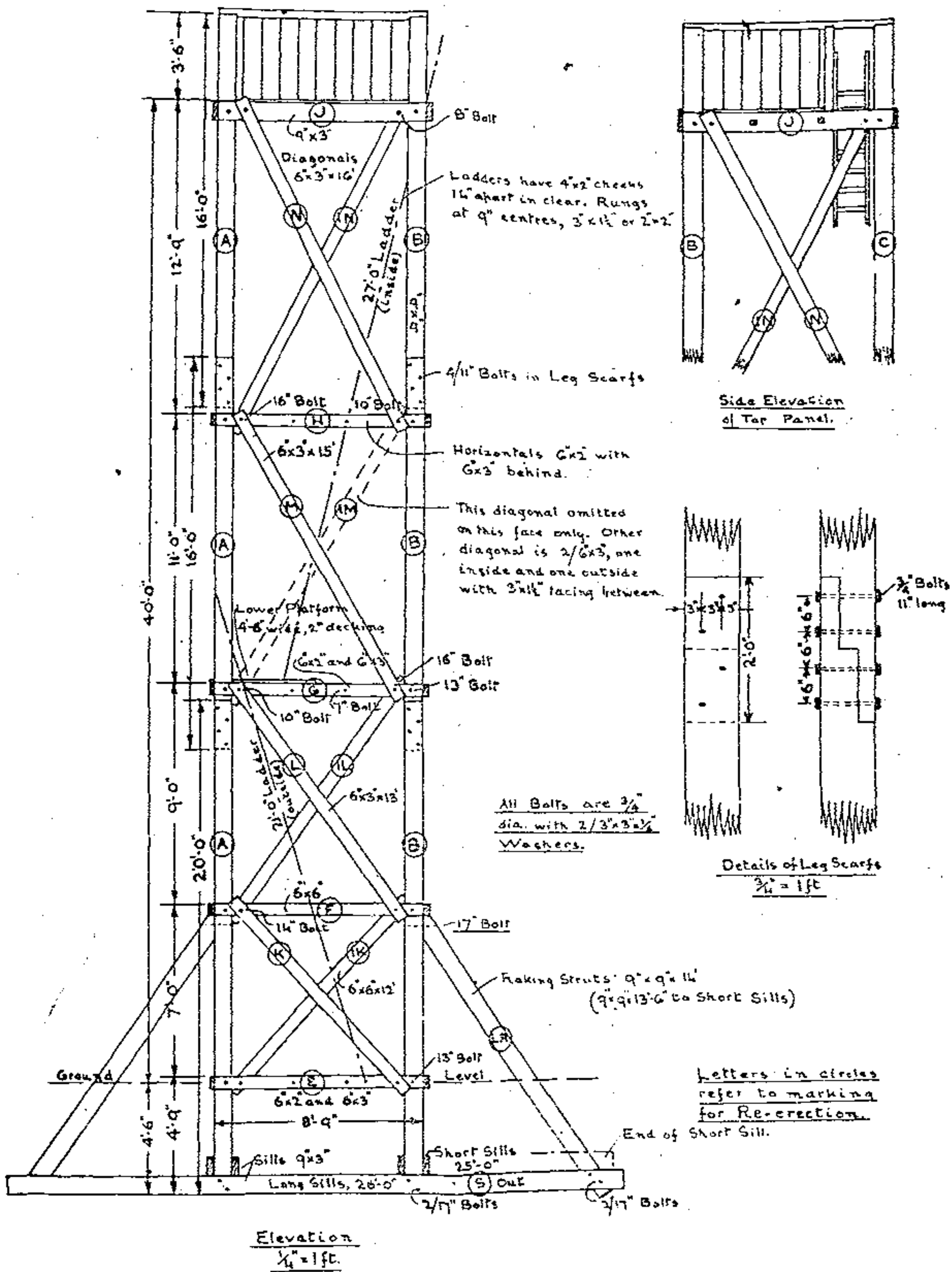
Jib cranes in use.



4.

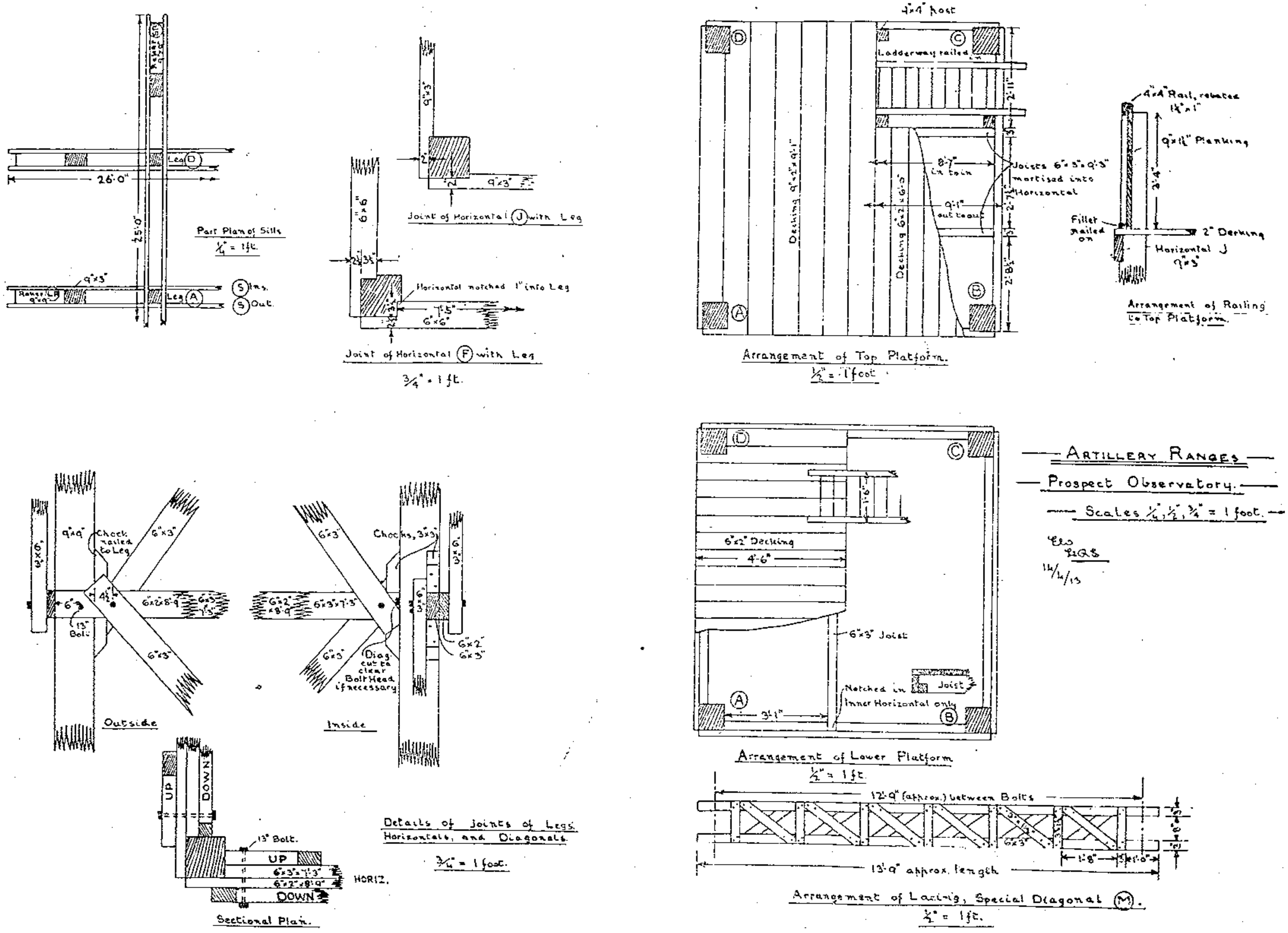
Observatory completed.

CONSTRUCTION OF AN OBSERVATORY FOR ARTILLERY RANGES.

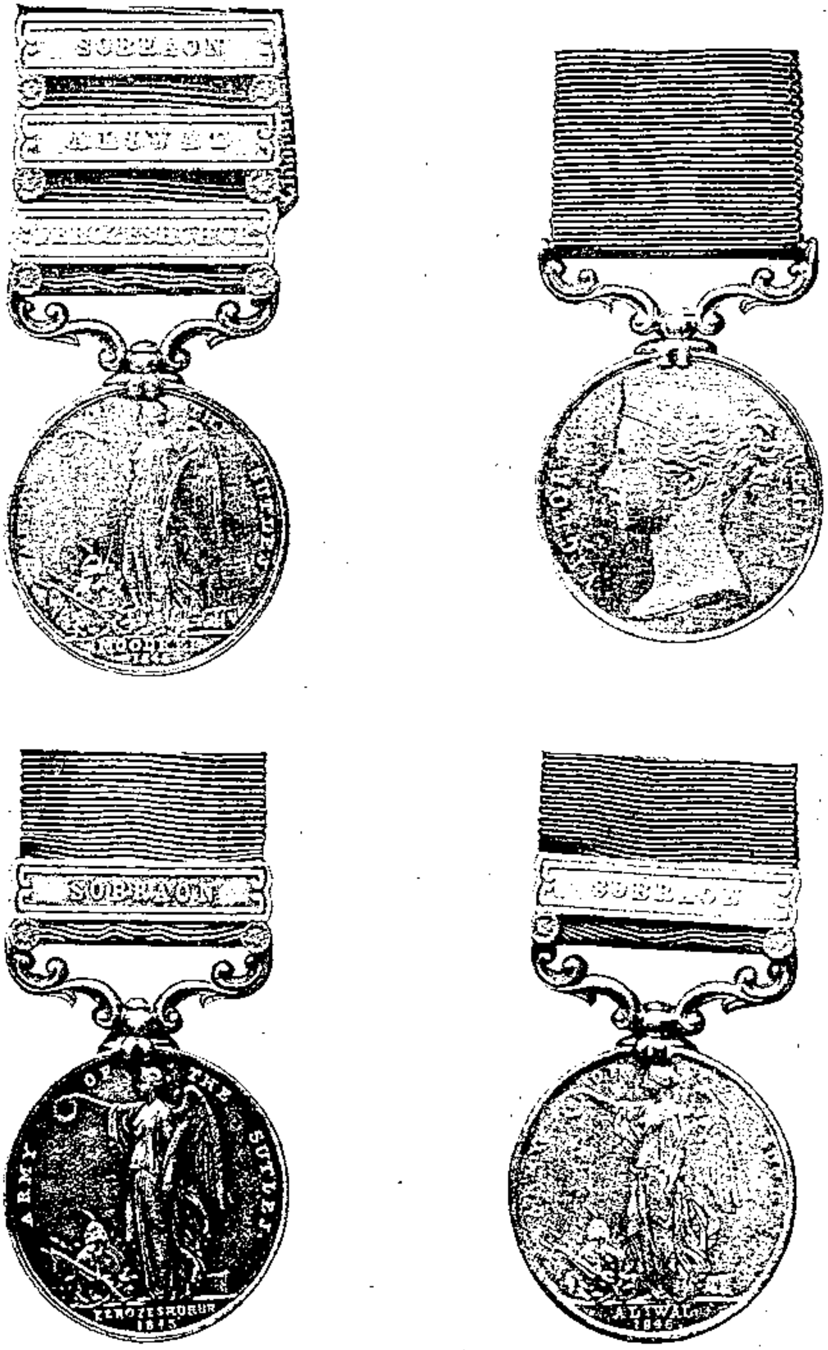


CONSTRUCTION OF AN OBSERVATORY FOR ARTILLERY RANGES.

PLATE II.



EARLY INDIAN CAMPAIGNS AND THE DECORATIONS AWARDED FOR THEM.



SUTLEJ CAMPAIGN. 1854-6.

EARLY INDIAN CAMPAIGNS AND THE DECORATIONS AWARDED FOR THEM.

(*Continued*).

By Major H. Biddulph, R.E.

The Sutlej Campaign, 1845-6.

The anarchy that ensued soon after the death of Runjeet Singh in 1839, culminated in the Sikh Army crossing the Sutlej and invading British territory in December, 1845. The Governor-General (Sir H. Hardinge), who was touring on the frontier at the time, immediately issued orders for the concentration of the British troops under Sir H. Gough, the C.-in-C., and marched with them himself.

Ten days after leaving their cantonments, and in which they covered 150 miles, the advanced portion of the British Army came into contact at Moodkee, on 18th December, with a detached corps of the Sikhs, thrown out in front of their main army and entrenched camp at Ferozeshah.

The battle began with artillery fire, while the British infantry advanced in echelon of brigades and deployed. Meanwhile the small force of British cavalry was directed to turn *both* flanks of the vastly superior force of the Sikhs. Both charges were executed with the greatest gallantry and success, and the infantry, advancing in echelon of lines, drove back the enemy with the bayonet, until night and weariness put an end to the battle.

Great confusion prevailed during the battle, the infantry had come into action, after a long march through deep sand, with stragglers stretching out for miles in rear; a dust storm was blowing, and many casualties were caused (as in other battles of this war) by the Native regiments, which lagged behind, firing into the European regiments in front.

The Sikhs lost some 17 guns and fell back on their main army at Ferozeshah.

The next day, H.M. 29th Foot, the 1st Bengal Europeans, and other troops arrived, and the Governor-General tendered his military services to Sir H. Gough, as second-in-command.

On the 21st December the army resumed its march, but, by the personal order of the Governor-General, the Commander-in-Chief was forbidden to commence the attack on the Ferozeshah entrenchments until (as arranged) Sir John Littler, who had slipped out of

Ferozepore, leaving a small garrison to oppose Sirdar Tej Singh, had effected a junction.

This took place early in the afternoon, and the assault on one of the longer faces of the camp then took place. Sir John Littler's division was on the extreme left. Sir H. Hardinge commanded the left wing of Gough's force and Gough commanded the right wing on the right flank.

The Sikhs numbered 47,000 men with 88 guns, according to their own estimate, the British numbered 17,000 men with 69 guns.

Littler's division assaulted the trenches prematurely and unsupported, and was driven back with immense loss; meanwhile the 2nd and 3rd Divisions attacked and penetrated the entrenchments, but could not clear the camp; the 1st Division (in reserve) also succeeded in penetrating the entrenchments. Night had now ensued, all the regiments and brigades were hopelessly mixed up and scattered, and the Sikhs kept up fire during a great part of the night.

In the morning Sir H. Hardinge and Sir H. Gough re-formed such troops as were at hand, and leading the line in person, 20 paces ahead, to prevent premature firing, swept the camp from end to end, driving the Sikhs from the field and capturing 74 guns.

Scarcely had this been effected, when Sirdar Tej Singh with 35,000 men and 100 guns arrived from Ferozepore.

The situation of the British was critical in the extreme; nearly all the artillery ammunition had been fired away, and the troops were worn out. The men were, however, immediately formed up and preparations for attack made, when Tej Singh, bluffed by the British, and doubly cautious after learning how the main army of the Sikhs had been turned out of their entrenchments, withdrew.

The British losses totalled 2,877; and, as before, the European regiments had to do most of the fighting. Sir H. Hardinge, who had served throughout the Peninsular War, considered the Bengal Native regiments much on a par with Portuguese troops, and that like them they had their fighting days. Unfortunately the 21st December was one of their non-fighting days.

The Sikhs now took up a position at Sobraon, with the Sutlej and their bridge of boats immediately in their rear, and spent their time entrenching themselves again. The chance of giving them a knock-out blow in this position was recognized by Sir H. Hardinge, and they were left there unmolested, pending the arrival of reinforcements and a siege train.

Meanwhile a Sikh Sirdar crossed the Sutlej higher up, threatening Ludhiana and the British communications. Sir H. Smith was detached to deal with him, which he did most effectively at the Battle of Aliwal on 28th January, 1846. Each arm was given full scope, the infantry advanced in line, covered by artillery fire, with cavalry on either flank. The enemy's left was turned and their line crumpled up and taken in reverse. The Sikh right, composed of Avitabile's crack battalions, clung to their ground to cover the passage of the Sutlej in rear, until H.M. 16th Lancers broke their square and the whole army was driven pell-mell across the river with the loss of every gun (67 in all), and at least 3,000 men.

The only point east of the Sutlej now held by the Sikhs was their bridgehead at Sobraon, and as soon as the siege train and reserve ammunition arrived, Sir H. Gough and Sir H. Hardinge planned the assault.

The Sikh entrenchments were held by 35,000 troops (exclusive of irregular cavalry), with 70 guns, while 50 pieces of heavy artillery were posted on the right bank. The British force *engaged* numbered 16,000 men. The engagement began by a heavy cannonading, but the infantry attack had to be launched prematurely owing to the expenditure of gun ammunition—one of the chief defects revealed by the campaign being the shortage of gun ammunition carried in the field by the artillery.

The 3rd Division, on the left, first penetrated the entrenchments, followed soon after by the 2nd and 1st Divisions on the centre and right. For an hour the battle raged inside the position before the Sikhs were broken, but by midday the enemy had been driven across the river; during their passage the bridge broke, and the river, which had risen several inches during the night, swept the Sikhs away by hundreds, while the horse artillery played upon them unceasingly from the river's edge. No less than 10,000 Sikhs perished that day, the position and sandbanks in the river were thickly piled with corpses, and 67 of their guns remained in our possession.

The British crossed the Sutlej the same day, and on the 20th February arrived at Lahore. Under the terms of the treaty of peace the remainder of their heavy guns, used in action, had to be surrendered.

The war occupied almost exactly two calendar months, during which four big battles were fought, over 200 pieces of artillery captured on the field, and nearly 7,000 casualties sustained in action, of which the few British regiments suffered no less than 3,600, out of a total strength of a little more than 9,000 of all ranks.

Sir H. Hardinge authorized, in the first instance, the medals for this war; and, following the rule followed in the Peninsula, directed that medals should be given for the battles only, the name of the first battle in which the recipient was engaged being on the reverse of the medal, while those of subsequent battles were on clasps attached to it.

Sutlej Campaign, 1845–6.

Obverse.—Crowned head of Queen Victoria. Legend: "Victoria Regina."

Reverse.—Victory standing beside a trophy, holding a wreath in her outstretched hand. Inscription: "Army of the Sutlej."

Exergue.—(*a*) "Moodkee 1845.
(*b*) "Ferozeshuhur 1845."
(*c*) "Aliwal 1846."
(*d*) "Sobraon 1846."
Clasps.—"Ferozeshuhur."
"Aliwal."
"Sobraon."
Mounting.—Silver scroll bar and swivel. This was the first medal issued with a swivel mounting.
Ribbon.—Dark blue with crimson edges, 1¼ in. wide.

N.B.—The correct name of the village that gave its name to the battle of Ferozeshuhur, is "Ferushahr." This battle honour is spelt officially as "Ferozeshah."

SUTLEJ CAMPAIGN, 1845–6 (Sir H. Gough, C.-in-C.).

Troops present at Moodkee, 18th December, 1845.

Cavalry :—Brigadier M. White, 3rd L. Dragoons.
2nd Brigade :—Brigadier J. B. Gough, 3rd L. Dragoons (wounded at Sobraon).
H.M. 3rd Light Dragoons.
The Bodyguard.
5th Bengal Light Cavalry.
3rd Brigade :—Brigadier W. Mactier, 4th L.C. (wounded).
4th Bengal Light Cavalry.
9th Irregular Cavalry.
Artillery :—Brigadier G. Brooke.
Horse Artillery :—1st Brigade, 1st, 2nd, and 3rd Troops.
3rd Brigade, 1st, 4th and 1 division of 2nd Troop.
Foot Artillery :—3-4th Battn. and 2-6th Battn.
Engineers :—Major R. Napier.*
Infantry :—
1st Division :—Major-General Sir H. G. Smith.
1st Brigade :—Brigadier S. Bolton, 31st Foot (killed).
H.M. 31st Foot.
24th and 47th Bengal N.I.
2nd Brigade :—Brigadier H. M. Wheeler,† 48th B.N.I. (wounded).
H.M. 50th Foot.
42nd and 48th Bengal N.I.
2nd Division :—Major-General W. R. Gilbert, 38th N.I.
2nd, 16th, and 45th Bengal N.I.
(Remainder of Division not yet arrived).

* Later F.M. Lord Napier of Magdala.
† Killed at Cawnpore, 1857.

3rd Division :—Major-General Sir J. M'Caskill, 9th Foot (killed).
Brigadier W. Wallace, 26th B.N.I.
H.M. 9th and 80th Foot.
26th and 73rd Bengal N.I.
(Remainder of Division not yet arrived).

Casualties :—12 British officers and 203 other ranks killed.
44 ,, ,, 613 ,, ,, wounded.

17 or 19 guns were taken, exact number is uncertain.

Sir R. Sale, of Jellalabad fame, was among the killed.

On the 19th December H.M. 26th Foot, the 1st Bengal European Regt., 11th and 41st Bengal N.I., the 2-4th Battn. and 4-4th Battn. Bengal Artillery arrived.

The 11th and 41st B.N.I. were left at Moodkee to guard the wounded, and the army marched on the 21st to effect a junction with Littler's division from Ferozepore.

Sir J. H. Littler left in garrison at Ferozepore the 27th and 63rd B.N.I., the 2-2nd Battn. Bengal Artillery, 3 guns of 2-7th Battn. Bengal Artillery and a detachment of Bengal Sappers ; and marched with the 8th Bengal Light Cavalry and the 3rd Irregular Cavalry, 5-1st Brigade and 3-3rd Brigade Bengal Horse Artillery, 4-6th Battn., 3 guns 2-7th Battn. and detail of 2-2nd Battn. Bengal Artillery, detachment of Bengal Sappers, the 7th Infantry Brigade (H.M. 62nd Foot, 12th and 14th B.N.I.) and 8th Infantry Brigade (33rd, 44th and 54th Bengal N.I.).

Troops present at Ferozeshah, 21st, 22nd December, 1845.

Cavalry :—Brigadier D. Harriott, 8th Ben. L.C. (wounded).
1st Brigade :—Brigadier M. White, 3rd L. Dragoons (wounded).
H.M. 3rd Light Dragoons.
4th Bengal Light Cavalry.
9th Irregular Cavalry.
2nd Brigade :—Brigadier J. B. Gough, 3rd L. Dragoons.
The Bodyguard.
5th Bengal Light Cavalry.
3rd Brigade :—Brigadier D. Harriott (commanding the Division).
8th Bengal Light Cavalry.
3rd Irregular Cavalry.

Bengal Horse Artillery :—Brigadier G. Brooke.
Bengal Foot Artillery :—Brigadier G. G. Dennis.
1st Brigade H.A. :—1st, 2nd, 3rd and 5th Troops.
3rd Brigade H.A. :—1st, 3rd, 4th, and 1 division of 2nd Troops.
4th Battn. :—2nd, 3rd and 4th Cos.
6th Battn. :—2nd and 4th Cos.
7th Battn. :—3 guns of 2nd Co.
Also detail of 2-2nd Battn.

Bengal Engineers :—Major R. Napier.
No. 6 Co., Sappers and Miners.
1st Infantry Division :—Major-General Sir H. G. Smith.
1st Brigade :—Brigadier G. Hicks, 47th B.N.I.
H.M. 31st Foot.
24th and 47th B.N.I.
2nd Brigade :—Brigadier T. Ryan, 50th Foot.
H.M. 50th Foot.
42nd and 48th B.N.I.
2nd Division :—Major-General W. R. Gilbert.
3rd Brigade :—Brigadier C. C. Taylor, 29th Foot (wounded).
H.M. 29th and 80th Foot.
45th B.N.I.
4th Brigade :—Brigadier J. McLaren, 16th B.N.I.
1st Bengal European Regiment.
2nd and 16th B.N.I.
3rd Division :—Brigadier N. Wallace, 26th B.N.I. (killed).
5th Brigade :—H.M. 9th Foot.
26th and 73rd B.N.I.
6th Brigade :—Absent.
4th Division :—Major-General Sir J. H. Littler, 36th B.N.I.
7th Brigade :—Brigadier T. Reid, 62nd Foot (wounded).
H.M. 62nd Foot.
12th and 14th B.N.I.
8th Brigade :—Brigadier T. Ashburnham, 62nd Foot.
33rd, 44th, and 54th B.N.I.

Casualties :—39 British officers and	681	other	ranks	killed.
82 ,, ,,	1,686	,,	,,	wounded.
	379	,,	,,	missing.

74 guns were captured.

It is to be noted that the troops that guarded the camp at Moodkee, and those that garrisoned Ferozepore, received the decoration for Ferozeshah.

Troops present at Aliwal, 28th January, 1846 (Sir H. G. Smith in command).

Cavalry Division :—Brigadier C. R. Cureton, 16th Lancers.
1st Brigade :—Brigadier G. J. M. McDowell, 16th Lancers.
H.M. 16th Lancers.
3rd Bengal Light Cavalry.
4th Irregular Cavalry.
2nd Brigade :—Brigadier R. A. Stedman, 1st Bengal L. Cavalry.
The Bodyguard.
1st and 5th Bengal L. Cavalry.
Bengal Artillery :—Major G. S. Lawrenson.
Horse Artillery :—1-1st Brigade, 1st and 3rd Troops, 2nd Brigade, 2-3rd Brigade.

Foot Artillery :—2-7th Battn.
Bengal Engineers :
Detachment, Sappers and Miners.
Infantry :—
1st Brigade :—Brigadier G. Hicks, 47th B.N.I.
H.M. 31st Foot.
47th B.N.I.
2nd Brigade :—Brigadier H. M. Wheeler, 48th B.N.I.
(Brigadier N. Penny, Supernumerary).
H.M. 50th Foot.
48th B.N.I.
Sirmoor Battn.
A Brigade :—Brigadier R. W. Wilson, 30th B.N.I.
H.M. 53rd Foot.
30th B.N.I.
(Wing 24th B.N.I., probably in garrison at Ludhiana).
A Brigade :—Brigadier C. Godby, 36th B.N.I.
36th B.N.I.
Nusseeree Battn.
Bengal Sappers and Miners.
Shekawati Brigade :—Major H. Foster.
Cavalry, Artillery, and Infantry, 1,200 strong.

Casualties :—	4 British officers and	147 other ranks	killed.
	25 ,, ,,	388 ,, ,,	wounded.
		25 ,, ,,	missing.

67 guns captured or destroyed.

N.B.—A good many details and drafts of other corps were present by accident, and the decoration was given to the garrisons of Ludhiana and Buddhowal Forts.

These included detachments from 2-4th, 4-4th, and 4-6th Battns. Bengal Artillery, Wing 24th B.N.I., etc.

Troops present at the Battle of Sobraon, 10th February, 1846 (Sir H. Gough, C.-in-C.).

Cavalry Division :—Major-General Sir J. Thackwell.
1st Brigade :—Brigadier J. Scott, 9th Lancers.
H.M. 3rd Light Dragoons.
8th and 9th Irregular Cavalry.
2nd Brigade :—Brigadier A. Campbell, 9th Lancers.
H.M. 9th Lancers.
2nd Irregular Cavalry.
3rd Brigade (on the right of the army, near Hurreekee Ford) :—
Brigadier C. R. Cureton, 15th Lancers.
H.M. 16th Lancers.
The Bodyguard.
3rd, 4th and 5th Bengal Light Cavalry.
Bengal Artillery :—Brigadier G. E. Gowan.

1st Division Horse Artillery :—Brigadier G. Brooke.

2nd Division Horse Artillery :—Brigadier E. Biddulph.

1st Brigade Horse Artillery, 2nd, 3rd and 5th Troops.

2nd „ „ „ 1st, 2nd and 3rd Troops.

3rd „ „ „ 1st, 2nd, 3rd and 4th Troops.

Foot Artillery :—Brigadier G. G. Dennis.

2-2nd Battn.; 3rd and 4th Cos., 3rd Battn.; 1st, 2nd, 3rd and 4th Cos., 4th Battn.; 1st, 2nd, 3rd and 4th Cos., 6th Battn.

Bengal Engineers :—[Brigadier A. Irvine]*.
Brigadier E. J. Smith.

Headquarters and 6 Cos. Sappers and Miners.

1st Infantry Division :—Major-General Sir H. G. Smith.

1st Brigade :—Brigadier N. Penny, Nusseeree Battn. (wounded).
H.M. 31st Foot.
47th Bengal N.I.

2nd Brigade :—Brigadier G. Hicks, 47th Bengal N.I.
H.M. 50th Foot.
42nd Bengal N.I.
Nusseeree Battn.

2nd Infantry Division :—Major-General W. R. Gilbert (wounded).

3rd Brigade :—Brigadier C. C. Taylor, 29th Foot (killed).
H.M. 29th Foot.
41st and 68th Bengal N.I.

4th Brigade :—Brigadier J. McLaren, 16th Bengal N.I. (killed).
1st Bengal European Regt.
16th Bengal N.I.
Sirmoor Battn.

3rd Infantry Division :—Major-General Sir R. Dick (killed).†

5th Brigade :—Brigadier Hon. T. Ashburnham, 62nd Foot.
H.M. 9th and 62nd Foot.
26th Bengal N.I.

6th Brigade :—Brigadier C. D. Wilkinson, 63rd Bengal N.I.
H.M. 80th Foot.
33rd and 63rd Bengal N.I.

7th Brigade :—Brigadier L. R. Stacey, 43rd Bengal N.I.
H.M. 10th and 53rd Foot.
43rd and 59th Bengal N.I.

Reserve 45th Bengal N.I.

At Rhodawalla, 73rd Bengal N.I.

Also present, wing 24th Bengal N.I., detachment 38th Bengal N.I. and 1 co. 12th Bengal N.I.

* Brigadier Irvine waived his right to supersede Smith, as he arrived in camp only just before 10th February.

† Sir R. Dick served with the 42nd Regt. in the Peninsula and at Waterloo.

Casualties :— 13 British officers and 308 other ranks killed.
102 ,, ,, 1,962 ,, ,, wounded.

67 guns were captured.

The troops at Rhodawalla, and those in reserve, and guarding the Commander-in-Chief's camp received the decoration for Sobraon.

The severity of the casualties in this short campaign of two months, the brunt of which was borne by the European troops, may be gauged from the following :—

3 Major-Generals and 4 Brigadiers were killed.
1 Major-General and 7 Brigadiers were wounded.

The European regiments lost 61 officers and 912 men killed, 128 officers and 2,520 men wounded, equivalent to 50 per cent. of the officers and 40 per cent. of the men.

Strength (approx.) 18. 12. 45.		Corps.	Killed.		Wounded.	
Officers.	Men.		Officers.	Men.	Officers.	Men.
27	518	3rd Light Dragoons ..	6	124	15	142
30	874	9th Foot	4	81	8	267
35	765	29th Foot	4	87	16	331
36	844	31st Foot	9	132	16	352
33	675	50th Foot	8	105	28	445
24	768	62nd Foot	8	91	11	204
26	795	80th Foot	5	63	8	168
26	640	Bengal European Regt. ..	9	80	11	312

Certain of the above regiments received small reinforcing drafts in January, 1846, which are not included in the strengths given ; also many individuals were wounded more than once, and increase the numbers of casualties recorded.

The combination of the Ferozeshah medal with clasps for Aliwal and Sobraon was not earned by a single individual of the Queen's troops, and by only a very few in the Company's service. One or two well-known collections contain faked medals of British infantry with this combination. For practical purposes the combination may be said to be non-existent.

Medals were issued to the 11th Irregular Cavalry, although this corps was not really in existence during the war. The regiment was ordered to be raised in January, 1846, and a nucleus of British officers and native ranks, drawn from units serving with the army in the field, was posted to it on paper. These individuals served in the field with their original units, but received their medal later on as the 11th Irregular Cavalry. Sir H. G. Smith's despatch written after the battle at Aliwal mentions a British officer of the "11th Irregular Cavalry" who had been posted in orders to that regiment.

Small *Native* detachments of the 4th Irregular Cavalry appear to have received the decorations for Moodkee and Aliwal. Faked clasps of this medal are *very* common; *e.g.*, "Aliwal" clasps are fraudulently added, or "Ferozeshuhur" or "Sobraon" clasps removed, in order to produce unusual combinations.

Medals were given to Prince Waldemar of Prussia and his suite, six in all (including two orderlies), who accompanied the Governor-General in the field as his guests; one of whom, Dr. Hoffmeister, was killed at Ferozeshah.

Officers of the Bengal Engineers who received medals for the Sutlej Campaign, 1845–6.

S.	Lieut.-Colonel	A. Irvine.	
S.	,, ,,	E. J. Smith.	
S.	Major	F. Abbott.	
S.	,,	B. Y. Reilly.	
S.	Capt.	W. H. Graham.	
S.	,,	W. E. Baker.	
M.F.S.	,,	R. C. Napier.	(Wounded). Brigade-Major.
S.	,,	J. W. Robertson.	
S.	,,	W. Abercrombie.	(Wounded).
S.	,,	H. Siddons.	
A.S.	Bt. Capt.	J. D. Cunningham.	(Political employ).
S.	Lieut.	J. Spens.	
A.S.	,,	R. Strachey.	
A.S.	,,	R. Baird Smith.	
S.	,,	A. D. Turnbull.	
F.	,,	A. G. Goodwyn.	(With Littler's force).
S.	,,	J. R. Becher.	(Wounded).
S.	,,	H. Yule.	
S.	,,	F. Whiting.	
F.A.	,,	E. J. Lake.	(Wounded). (Political employ).
S.	2nd Lieut.	W. D. A. R. Shortt.	
M.	,,	J. E. T. Nicolls.	
A.S.	,,	G. P. Hebbert.	(Wounded).
S.	,,	C. J. Hodgson.	
S.	,,	D. G. Robinson.	
(F.) A.S.	,,	A. Taylor.*	(With Littler's force).
S.	,,	G. Sim.	
S.	,,	C. S. Paton.	

M signifies Moodkee.
F ,, Ferozeshah.
A ,, Aliwal.
S ,, Sobraon.

* Taylor received the decoration for Ferozeshah as he was on duty in the Ferozepore Cantonment, but he was not present at the battle. In the same way many of the officers with A. or S. before their names were not actually present on the battlefields of Aliwal and Sobraon.

TRANSCRIPT.

RECENT PROGRESS IN GAS-FIRE SCIENCE.

A Paper read by H. James Yates, F.C.S., M.I.Mech.E., *at the British Association*, 1913.

The coal fire is a heating contrivance which, however cheerful in appearance, does not, in its nature, make for great economy in the use of fuel. Yet the motive that gave rise to the introduction of gas heating as a substitute for coal heating was not economy but convenience, the question of economy came later. Considerations of hygiene and of greater thermal efficiency have come last in order and all three are now undergoing continual discussion, experiment, and development.

Utility being the first motive, the earliest gas fire, being intended to do the work of a coal fire, under conditions of greater convenience, was an imitation of the coal fire. It either occupied the fire space in the ordinary coal grate, or (more frequently) was placed within a similar cavity in a separate stove, which was set in front of the discarded coal grate. In either case, it consisted of a series of Bunsen burners, arranged along the front bottom bar, the flames of which played or impinged irregularly upon iron frets, wisps of asbestos filaments, or, more generally, perforated balls of refractory material, which were intended to resemble coal; these various refractory bodies were heated to low incandescence by immersion in the flames, after the gas had been lit for some time. This contrivance, whatever its convenience, resembled its prototype, the coal fire, in losing much of its heat up the flue, and in yielding only an irregular and inadequate return in the form of radiant heat from the fuel consumed. The improper way in which the flame impinged upon the refractory material also greatly impaired the completeness of combustion, a fact which not only involved waste of fuel, but was liable to occasion an escape of harmful combustion products into the room, especially when the chimney draught was poor, or the flue outlet of the gas fire badly constructed.

The gas-fire idea having been embodied in these early crude forms, it was gradually realized that on such a basis gas was no match for coal in point of cost, and the question of economizing devices came to the front. The manifestly great flue losses led to the heat-economizing efforts being all directed towards delaying the escape of the combustion products until they should have communicated as large a proportion as possible of their sensible heat to the body of the stove, to be afterwards transmitted into the apartment in the form of hot-air currents from the stove body. In other words, these early efforts in gas-fire economy aimed at *concentrating on convected heat.*

A shape which these convection devices usually took was the forming of chambers in extended flues within the stove body. The hot combustion products on passing through these chambers or flues, imparted most of their sensible heat, by conduction through the walls, to currents of cold air from the room, which thus became warmed by passing over the outside of the walls of these chambers, and which issued therefrom as hot-air convection currents into the room through perforations provided for the purpose. But the heat economy thus realized was accompanied by a bad physiological effect, inasmuch as the convection currents leaving the stove were so hot that the dew point of the air of the apartment was unduly raised, and its degree of saturation lowered; the skin and the mucous membranes of the throat and nasal passages of the occupants offering ready sources of moisture, "dry" sensations, prickling of the skin, and other disagreeable symptoms were complained of. Anyone entering a room so heated could generally "smell the gas fire," as it was expressed, partly owing to the cause already mentioned, but perhaps more to the escape of products of combustion into the room, through faulty construction of the stove, and to the burning of dust by contact with the overheated "convecting" chambers of the stove. Further, owing to the air of the room being hotter than the walls, persons sitting near these, while feeling discomfort owing to the overheated air, might yet experience chilling sensations owing to radiation from their bodies to the cold walls. These drawbacks engendered a widespread prejudice among the public and the medical profession against gas fires.

It was the personal discomfort which such stoves occasioned to myself that led me to take up the matter and endeavour to devise a new type of gas fire free from these defects. Even after my work in this direction had made substantial progress, it was most difficult to get the public to grasp the real causes of the discomforts then attendant on the use of a gas fire, and it was no speedy or easy task to educate them to realize that such troubles were not inherent in the gas fire as such, but that they were merely evils inseparable from the mistaken practice of "high-temperature convection" in moderate-sized apartments, whatever the source of heat. A general impression prevailed that in some mysterious way gas used for heating must necessarily produce disagreeable effects from which a coal fire is free. It was overlooked that the combustion of coal is after all to a large extent the combustion of coal gas, and that whereas the coal fire produces and burns crude gas with all its native impurities unremoved, the gas fire burns a concentrated and purified gas. It was not realized that nothing can arise from the combustion of coal gas that does not also arise from the combustion of coal, and that, therefore, any ill-effects associated with the use of the earlier crude gas fires cannot be rightly ascribed to the *nature* of gas heating, but must be due to some radical fault in the *methods* of applying it.

This being so, I realized that the only way to remove the popular prejudice was to remove its cause. First of all, it was clear that the temperature of the convection currents ought to be reduced so as to effect a corresponding reduction in the moisture-absorbing capacity of the air of the room. It then occurred to me that the old idea of enhancing the total heating efficiency of the fire by increasing the "*convected*" heat effect in the manner described was a mischievous one and the source of all the trouble; and that the true remedy must be sought for in increasing the "radiant efficiency" of the fire to the maximum possible with consequent decrease in the amount of "convected" heat.

The known advantage of radiant heat being that it warms the walls, the furniture, and the occupants of the room rather than its atmosphere, the problem was how to increase efficiency in the direction of radiation so as to compensate, both in heating power and in economy, for the reduction in the temperature of the convection currents. The gas fire, which hitherto has been a haphazard evolution from the coal fire, now became the subject of a reasoned and drastic revolution. The convection chambers were dispensed with. The deep fire chambers became a shallow space in the front of the apparatus, its depth only that of one piece of refractory material. The erratic arrangement of fireclay lumps was superseded by placing two or three such pieces one above the other exactly over the flame, so as to form an envelope for it. A little later a more marked step in the evolution of the new radiating fire consisted in joining the two or three fireclay pieces into one, and thus making the fire front consist of a series of hollow fireclay columns (now known as radiants), perforated in a design expressly contrived to promote uniform heating of the column throughout, and with each flame rising into the cavity of its radiant. Care was taken to prevent any impingement on the inner cone of the flame; by this means, and also by using a correctly designed burner, and making due provision for the proportionment of the gas and air supplies, perfect combustion was ensured. A further important improvement was the dispensing with the cast-iron front bars hitherto used to retain the loose fireclay lumps, and the replacing of these bars by one slight horizontal rod. This arrangement not only left no obstruction in the path of the radiation, but vastly improved the appearance of the fire. The effect of these radical changes has been that the greater proportion of the energy developed by the combustion of the gas around and in contact with the radiants is transmitted into the apartment as radiant heat. This radiant heat quickly makes its warming effect felt by the occupants; yet, inasmuch as it passes through the air without sensibly warming it, the discomforts formerly occasioned by the now discarded "convection" methods are at an end. The walls and the objects in the room, becoming warmed by absorbed radiant heat, no longer abstract heat from the occupants, and further, they gradually warm the air to a moderate degree by convection currents which, being necessarily at a low temperature, do not reproduce the former excessive moisture-absorbing condition of the air.

This gradual warming of the air by contact with the objects in the room naturally cannot begin for some little time after the fire has been lighted, not indeed, until the radiant heat of the fire has warmed the walls and furniture. From the outset, however, there is a certain proportion of convected heat from the stove (but at a low temperature, owing to the absence of the old special heating chambers) and this primary or direct low-temperature convection at once begins to gently raise the temperature of the air, thus anticipating—and later on co-operating with—the secondary low-temperature convection from the walls and furniture, in suitably warming—but not overheating—the air. It will thus be seen that although the earlier types of gas fire may have made their heating effect more quickly apparent, yet in the gas fires of to-day the primary convection is also doing its work from the first, though in a less conspicuous and more healthful way. In this way radiation has taken the place of convection as the mode of heat transference principally aimed at in gas-fire design.

Having thus traced the evolution of the modern gas fire, I come next to that on which the modern gas fire so largely depends, viz., radiation, to the problem of increasing which, much research has been devoted. Progress towards higher radiant efficiency in a fire can be measured only when a reliable method of estimating the latter is available. The present accepted method is that adopted by the Joint Committee appointed in 1907 by the Institution of Gas Engineers and the University of Leeds, for the Investigation of Gas Fires; this method, which was originally suggested to the Committee by Professors W. A. Bone and William Stroud, is essentially a radiometer-*cum*-thermopile method. Part of the radiant energy is directly determined (in kilogram centigrade units) by using a radiation calorimeter (or radiometer), and the remainder by means of a thermopile and galvanometer, standardized against the radiometer for each experiment. A full description of the method was included in the Committee's First Report as published in *Trans. Inst. of Gas Engineers*, 1909. Various other methods have been suggested, both electrical and calorimetrical, but so far as I am aware, no authoritative vindication of their reliability has as yet appeared. The most recent suggestion, viz., that of a calorimeter, to absorb all the radiation from a fire, fails for one or other of two reasons. In the one case, if it be larger than the fire, then the water capacity becomes very great, and difficulties occur in ensuring perfect circulation, also heat is lost from the outer surface by convection and radiation. Alternatively, if the instrument be so small as to necessitate its being placed very close to the fire, the free access of air to the fire is interfered with, thus upsetting the natural action of the air currents and setting up abnormal conditions.

The testing of gas fires is a much more difficult matter than might be imagined. Considerable experience in heat measurement is called for, and until recently this has not been available in commercial testing laboratories, and even now the number of trained workers who have turned their attention to this branch of research in connection with gas fires is very limited. And in the absence of such special experience, results obtained even by otherwise careful and competent workers are of doubtful value, owing to unsuspected errors in judgment or inherent defects in the methods employed.

Manufacturers of gas fires are under a great obligation to the scientific work organized and carried out under Professor Bone's supervision at Leeds University, by the Joint Committee appointed by the University and the Institution of Gas Engineers, which has greatly stimulated further enquiry on the part of manufacturers.

Ten years ago even the best deep fires did not afford more than 30 to 33 per cent. of the net heat of combustion of the gas in the form of radiant energy. In the effort to secure increased radiation (by which I mean a higher percentage of the heat developed by the combustion of a given amount of gas delivered as radiant energy) it has been found, as was to be anticipated, that to advance from these low figures to 45 per cent. is much more easy than to make a further increase above 45 per cent. The adoption of the shallow-fire principle, and the dispensing with the front bars, to which I have already referred, was responsible for an increase from 30 per cent. to somewhere about 42 per cent. From that point, by attention to the perfecting of the design and proportion of the burners and back-bricks, and—most important of all—that of the radiants, we have been successful in further raising this figure to 48—50 per cent., and indeed, in some instances, to as high as 55 per cent.

From the first, gas fires had been made considerably smaller in width than the average coal fire, and when the new shallow-fronted radiation gas fire had been evolved, there still remained a general tendency to keep these fires down to a similar narrow width, the impression probably being that inasmuch as gas fires give a more concentrated heat, a smaller fire space was adequate. I became convinced, however, that if gas fires were to take the place of coal fires for heating the largest domestic apartments equally well as the smallest, it would be necessary that gas fires should be made available having a fire space as wide as that of the coal fire. Although this development was simple in appearance, it involved constructional problems which were only solved after considerable experiment; the result has been that gas fires of the new type are now made as wide as 17 in. and 21 in., fires of that size being capable of heating rooms up to a cubical content of at least 4,000 cubic ft.

The problem of total heating efficiency is, however, not the only one which makers of gas fires have to solve; the equally important question of ventilating effect must also be considered, for a properly constructed gas fire should effectively ventilate as well as heat an apartment. It is obvious that no fire could be considered as hygienically perfect, which, when connected with a chimney flue in the ordinary way, and subjected to a moderate chimney draught, allows any products of combustion to escape into the room; but provided that this elementary hygienic requirement is fulfilled, the question of "hygienic efficiency" resolves itself into the amount of excess air over and above that required for combustion, which can be drawn up the flue per cubic foot of gas burned, when the fire is so connected and fixed. There is obviously no object served in testing or discussing "hygienic efficiency" or "ventilating effect" except in relation to conditions of ordinary chimney draught, because no gas fire ought ever to be used except it be connected with a chimney or flue leading into the outside atmosphere.

It is not difficult to design and proportion the flue vent and the canopy of a gas fire so as to ensure the drawing up the flue of a large volume of air, thus producing good ventilation. The real difficulty is to avoid drawing this large excess of air over the upper portion of the "radiants," thus cooling them and unnecessarily diminishing the radiant efficiency of the fire. In other words, whereas it is comparatively easy to achieve "ventilation" at the expense of "radiant efficiency," a really scientifically constructed fire should ensure an equally good "ventilation" without sacrifice of radiant efficiency, which although not so easy, is by no means an impossible matter.

In this connection, my own researches have convinced me of the importance of preserving a certain adequate vertical distance between the top of the radiants and the bottom of the canopy of a gas fire, so as to avoid drawing the induced "ventilating" air over the upper portion of the radiants; experiment has proved that such a constructional feature, combined with an adequate flue vent, ensures a much higher radiant efficiency than another type (in point of fact older, but which it has been recently sought to revive), in which the canopy is brought down to overlap (or nearly so) the top of the radiants. As the relative merits of these two types of construction have recently been under discussion, it may be of interest if I append the results of an investigation of the matter in my own laboratory, which seem to prove conclusively the marked superiority of the first-named type of construction.

To ascertain the total heating efficiency, each type of construction was tested by determining the radiant efficiency, using the Leeds University method, and at the same time determining the amount of heat lost through the chimney flue. The total of these two, deducted from the heat developed by the combustion of the gas, gives the amount of convected heat. It is obviously impossible to estimate directly the convected heat, since the radiant energy also eventually makes itself sensible in this form.

The fires were tested under a series of parallel conditions. In the first case, the flue outlets were blocked up; this neutralized any possible cooling action of the flue draught on the radiants. The second test was one with the flue outlets open. In the third the two stoves were connected to a chimney. It ought to be remarked that changes in the meteorological conditions sometimes influence the amount of air withdrawn from the room by a given chimney to a surprising degree.

It will be seen from the figures that the lowering of the canopy, as had been anticipated, resulted in a lowered radiant efficiency and a lowered total heating efficiency, due to the cooling influence on the radiants of the air drawn over them.

In concluding, it should be stated that the entire change in the construction principle of gas fires which has just been described, has led to an equally great change in the attitude of the medical profession and the public towards the use of gas for heating. As a result there are to-day upwards of 350,000 gas fires in use in London alone, and there is every indication that each succeeding year will see a further substantial advance in the adoption of this method of domestic heating in preference to the coal grate, which has for so long been the chief and almost the only means available for the purpose, and that thus the atmosphere of large towns will become increasingly clear through the smokeless nature of gas-fire combustion.

TABLE ILLUSTRATING INFLUENCES OF INCREASED DRAUGHT THROUGH A LOW CANOPY.

Fire.	Consumption at N.T.P. cu. ft. per hour.	Nett Cal. Val. K.C.U. per cu. ft.	K.C.U. Developed by Gas.	K.C.U. Radiated.	Flue Outlet.	Percentage of Nett Heat of Combustion. Radiated.	Removed by Flue Gases.	Convected.
Canopy well above radiants as described.	24·15	144·8	3496	1730	Blocked up	49·5	—	—
	24·75	143·6	3553	1710	Open but not connected to chimney	48·1	27·2	24·7
	25·24	143·3	3617	1730	Connected to chimney	47·8	30·8	21·4
Canopy brought down to top of Radiants.	24·73	144·7	3578	1562	Blocked up	43·7	—	—
	24·17	145·7	3522	1373	Open but not connected to chimney	39·0	36·6	24·4
	23·77	146·9	3493	1223	Connected to chimney	35·0	42·0	23·0

TABLE SHOWING EFFICIENCY RESULTS OF DIFFERENT SIZED MODERN FIRES ATTACHED TO A CHIMNEY 30 FT. HIGH, THE CANOPY IN EACH CASE BEING WELL ABOVE THE RADIANTS—AS DESCRIBED.

Fire.	Consumption at N.T.P. cu. ft. per hour.	Nett Cal. Val. K.C.U. per cu. ft.	K.C.U. Developed by Gas.	K.C.U. Radiated.	% CO_2 in Flue Gases.	Temp. of Flue Gases.	Percentage of Nett Heat of Combustion. Radiated.	Removed by Flue Gases.	Convected.
10″	25·24	143·3	3617	1730	·90	117°C.	47·8	30·8	21·4
14″	34·02	145·5	4950	2490	·80	104	50·3	30·7	19·0
17″	42·62	143·2	6102	3003	·93	109	49·2	29·4	21·4
21″	52·90	144·8	7661	3903	·77	101	51·0	26·4	22·7

NOTE.—The consumptions shown above are somewhat higher than is necessary in general practice. They were determined by the type with lowered canopy which required more gas to make the radiants incandescent to the top.

In arriving at the above figures for percentage of heat radiated, it has been thought necessary to make a correction, during the radiation determination, for the convected heat which is absorbed by the Radiometer, and which would otherwise figure as radiated heat. This correction is not specifically mentioned in the Report of the Committee which first investigated and used the method at Leeds, and but for this correction the percentage of radiant heat would stand approximately five units higher in each case than the above figures.

NOTICE OF MAGAZINE.

REVUE D'ARTILLERIE.

May and June, 1913.

CAN THE ENEMY'S ARTILLERY BE DESTROYED?

By C.D.—Destruction can be of two degrees, the *personnel* can be killed, or the *matériel* destroyed, and the latter must necessarily include the former, since the case of detachments leaving their guns is unimaginable. The regulations admit the destruction of the *matériel* as possible, without excessive expenditure of ammunition, if the range is not too great—say 2,000 to 2,500 metres. With guns in the open this may be considered a certainty, but to reach batteries of which the locality is unknown, either because they have not yet fired, or because they are only betrayed by sound, shell with time fuze distributed over a wide and deep zone is necessary. It is hardly likely that the density of this fire will cause serious damage, but such concealment is not often obtainable; flashes, smoke, or dust will generally betray the position.

It seems certain then that although the whole of the enemy's artillery cannot be silenced, still the detachments of all guns in sight may be killed and many of the guns destroyed and 30 to 90 per cent. of losses inflicted on batteries of which the direction only is known.

This result will be contested, and will not be gained without loss. Without false shame the expression "artillery duel" must be re-adopted. In this duel one side will inflict on the other greater losses than it has itself suffered, still in the latter some few guns will be available up to the moment of the assault. It is to be hoped that this will be on the enemy's side, and that the very concealment that has saved the guns may render them less dangerous at the critical moment.

TALKS ON ARTILLERY.

By Major P. Muller.—Contains hints to artillery majors in regard to the training of their batteries, the results of personal experience. The following heads are discussed:—(1). General observations on taking up positions. (2). The use of maps divided into squares. (3). Choice of observing stations. (4). Watching the progress of events in the field. (5). Use of telephones. (6). Firing over the heads of one's own troops. (7). Problems connected with masked positions. (8). The issue of orders, including the reconnaissance to be carried out by the Major whilst the batteries are being lead to their positions.—(*To be continued*).

ORIENTATION BY MEANS OF THE SUN.

By Lieut.-Colonel J. Favret.—A glance at the sun is quicker than having to stop to use a compass. The article is accompanied by diagrams showing the hours at which the sun passes the cardinal points of the compass for the principal epochs of the year at Chalons and Fez (Morocco). These diagrams are sufficiently accurate for any point within 4 degrees of latitude of these towns. For differences in longitude it is necessary to add or subtract as many times four minutes as there are degrees of difference in longitude.

THE ESSENTIALS OF A RANGING APPARATUS.

By Capt. E. Bourboulon.—The *lunette de batteries* carried with the 75-m.m. gun only imperfectly fulfils requirements. The Rimailho theodolite carried in 155-m.m. batteries allows of all problems connected with ranging to be satisfactorily solved. The German *Nichtkreis*, mounted on a metallic stand, and provided with a compass, acts on the same principles. Recently a field telemeter has been tried and attempts have been made to add to it an instrument for measuring angles, but the combination contains no compass. Whatever may be the position of the observing station with reference to the battery, the instrument should allow of the line of fire being obtained by some simple operation, if possible before the arrival of the battery. There should be two instruments with each battery. It should be extremely portable and easily set up and adjusted. A compass should be attached.

THE GERMAN FIELD ARTILLERY PRACTICE CAMPS OF 1912.

Translated by Capt. G. Rogers-Vasselin.—The reports of the practices carried out in 1911 and published in the *Artilleristische Monatschafte* showed that the Germans are closely copying French methods of ranging. The 1912 reports show that they are still in the period of trials that the French have completed long ago.

The article is interesting as showing the German progress in the art of manœuvring and employing field artillery, and contains some useful suggestions for overcoming the usual difficulties.

UNIVERSAL SHELL.

By Capt. H. Peloux (*continued from the April number*).—3rd Group, detonating charge in the head. To this group belong the most recent and most perfected shells, and to it, or to the 4th group, will probably belong the shells of the future.

The following are described and illustrated:—Sokolooski's improved shrapnel, 1888. The double action shell of Daniel van Essen, 1903. Bursting shrapnel by the same, M/1906, M/1907, C/1910. The German light howitzer shell, but very little is known of this. Puff's shell, 1906. Keller's shell. Schneider's shell.

The general principle of this group is to keep the common shell portion in front. The rear, or shrapnel portion, with bursting charge in the base, can be burst with time fuze, when the front, or shell portion, continues its flight in practically the same trajectory with nose to the front. The bullets are surrounded with trinitro-tolnol or other explosive, which merely burns away when ignited by the time fuze. If the front portion separates easily, the cone of dispersion of the bullets is not unduly opened, and the front portion has sufficient residual energy to pierce the shield of a gun and burst on impact, or immediately in rear of the shield, under the action of a percussion fuze which may be set with or without a delay action. In some models a smoke-producing composition enables the burst to be observed separately from that of the shrapnel portion. Against obstacles or fieldworks the whole shell bursts practically simultaneously under the action of the percussion fuze, the trinitro-tolnol of the shrapnel portion being detonated in this case.

The 4th group contains only the most recent models of Krupp's shells. In one the shrapnel portion is in the head and the shell portion in the base, but it is probable that the explosion of the shrapnel would cause the base to diverge from its course, at any rate its penetrative power would be small. In a second model there are four charges, the shell portion being in the head. When the shell is fired with time fuze as shrapnel, the head carries with it, besides its own charge, a second attached to it by a small thick walled cylinder. This cylinder is intended to steady the head in its flight, as well as to add to the destructive effect of its explosion. When fired as shell with percussion fuze all the charges detonate simultaneously.

Many of the shells described have not been constructed, and the results of trials of others are secret. The last models of Erhardt & Krupp, however, have been frequently tested, and the results are known. When fired as shrapnel with time fuze it appears that the results are just as good as with the old ammunition, provided the aim is so good that the shell portion reaches the target as well as the shrapnel. Against troops in the open, therefore, the result is slightly inferior, as the shell portion makes a fougasse, and many fragments are buried in the ground. Against the *personnel* of artillery in blinded cover the universal shell is far superior to shrapnel, for in both cases the shrapnel bullets are ineffective, but in the former the head penetrates and bursts among the detachment. The effect as shrapnel might be increased by arranging, after the bullets have been discharged, to shatter the envelope, so that the fragments may be added to the bullets. Puff's model realizes this idea.

Used as explosive shell against troops in shelters with percussion fuze, a well-aimed shot is very deadly, as the shrapnel bullets are added to the fragments of shell. With time fuze the universal shell has, for similar reasons, more effect than the old explosive shell, but against artillery in covered positions, and leaving out of account the few direct hits, it is better to fire the shell as shrapnel with time fuze than as shell with time fuze. In the latter case the whole shell explodes at once, but in the former the head goes out and bursts on or behind the shield, putting the detachment *hors de combat*.

It appears paradoxical, but, owing to the fact that the shrapnel bullets of the universal shell are surrounded with trinitro-tolnol, these shell actually contain more high explosive than the ordinary common shell, and as the effect against resisting objects depends on the amount of explosive, the new shell are more effective than the old, especially when the percussion fuze is filled with a delay action.

In an appendix are given in tabular form the results of certain experiments.

VARIOUS INFORMATION.

An automatic alarm for telling when a crane is overloaded is described, and is the invention of Philip F. Felice, of Brussels.

A note is given on Bernard's planimeter, which is said to be good and cheap. Its box contains tables by which areas shown on various scales can be readily found.

A short description, with photograph, is given of the Krupp 28-c.m. howitzer, mounted on travelling carriage. The wheels can be filled with wide plates to prevent their sinking into even soft ground. Elevation can be given from + 20° to + 65°, and training 5° on each side of the centre. The shell weighs 750 lbs. and contains 38 lbs. of explosive. There are eight charges, the muzzle velocity ranging from 180 to 340 metres a second. The maximum range is 10,100 metres.

In Germany certain cast horses are retained with their units for duties in barracks, and their rations are paid for from a special fund. In consideration of a payment to this fund officers can use them for going to barracks, rifle range and other military duties.

In Switzerland a form of man-harness is being tested, for moving guns in action. The German field gun and light howitzer are provided with drag-ropes. In France man-harness is issued to the 75-c.m. field gun.

July, 1913.

ARTILLERY IN THE GRAND MANŒUVRES.

By "C.D.," who suggests reducing the numbers of guns on these occasions from four to two per battery. This would enable men to be found for staffs, scouts, and communication services, a thing impossible at present. Of the two wagons with these guns, one would represent the first line, and the other the second. The spare teams and drivers, etc., could be utilized as additional scouts, artillery park with the *corps d'armée* and so on. Discussion of this suggestion is invited.

THE EVOLUTION OF MOUNTAIN ARTILLERY.

An interesting article by Capt. L. Amene, of the Colonial Artillery, and well illustrated. After a short historical sketch, the undermentioned are described :—Krupp's guns varying from 40 m.m. to 76·2 m.m., and the mountain howitzer of 100 m.m. Erhardt's guns of 1906, 1907, 1909 and 1911 with special mention of the *canon puissant* L. 19, M. 1911, and the mountain howitzer of 105 m.m., L. 12, M. 1912. The guns of Skoda, Vickers-Maxim, Deport, Saint Chamond and Schneider. The results of certain experiments with the last named are described. The conclusions he arrives at are that six mules and no more should be capable of carrying the gun and its carriage, cradle, buffers, etc. 75 c.m. (3 in.) is a good average diameter for the bore, $6\frac{1}{2}$ k.g. ($14\frac{1}{4}$ lbs.) a fair weight for the projectile, and 350 metres a second a satisfactory muzzle velocity. The article is accompanied by tables comparing the characteristics of the principal guns, their ammunition, etc.

Talks on Artillery.

This article is continued and suggestions are made in regard to :—

IX. Ranging on crests.
X. Firing into the dead ground in front of the mark.
XI. The use of aiming posts.
XII. Ranging on puffs of smoke with the help of the compass.
XIII. Firing on flashes.
XIV. Firing on slopes descending towards the observer.
XV. Neutralizing fire.
XVI. How to discover when an effect has been produced on artillery that cannot be seen.
XVII. Distant fire.
XVIII. The range that should be given by the gunner to the infantry soldier who asks this information.
XIX. Procedure to be adopted if the corrector readings are surpassed during ranging.
XX. Fire against swarms of infantry in small distinct bodies.
XXI. Firing against woods.
XXII. Firing against towers.

The Chatillon-Panhard Tractor.

A good description of this motor, accompanied by several photographs and a plate of diagrams, is given by Commandant L. Ferrus. Increased power is obtained by using the front wheels as driving wheels, as well as the hind wheels. This necessitates also using the hind wheels for steering. The transmission is very ingenious and has been found very successful. The writer considers this tractor an ideal motor for military purposes ; the results obtained were extraordinarily good.

Various Information.

A short description is given of the German 13-c.m. (5·12-in.) siege gun.

Alexander Humphrey, an American, has invented a "torpifying bullet" for rifles, which he claims as an eminently philanthropic invention.

The United States have produced a comparatively cheap target representing an electric light projector, against which their artillery can obtain the practice indispensable for hitting such objects.

The Dutch are experimenting with powders that produce no flash. These are of local and of German manufacture.

August, 1913.

Note on the Effect of Wind on a Moving Body.

By P. Charbonnier, Chief Engineer of Naval Artillery.—The usual formulæ being derived from the consideration of weights concentrated at a point, take no account of the shape of the body. This the writer proceeds to do, studying the cases of transverse and head winds. With side winds, the longer the body (or projectile) the greater the lateral deviation, which is also considerably affected by the shape of the head. With a head wind the shape makes very little difference to the range.

RANGING APPARATUS OF THE GERMAN 96-M.M. GUN.

By G. Roger-Vasselin, Capt. of Artillery.—These apparatus form two distinct groups. The older group comprises the hausse-niveau (Libellen-Aufsatz) with telescope (Visierfernrohr) and level (Libelle).

The dial sight (plaque de repérage) (Richtfläche).

The aiming post (jalon de repérage) (Richtlatte).

The clinometer (cadran de pointage) (Winkelmesser).

The newer group consists of the panoramic sight (Hausse panoramique) (Rundblick—or Panorama fernrohr).

The director with compass (Cercle de pointage) (Bussolenrichtkreis).

The lunette à ciseaux (Scheren fernrohr).

The article is well illustrated with photographs and diagrams.

A. *1st Group.*—These instruments are well known, and details can be obtained from the French or German publications describing them. A short description of each is, however, supplied.

B. *2nd Group.*—This group consists of appliances more especially suited for indirect laying. The ordinary sight can be also used for this purpose, but its range is limited by the narrowness of the opening in the shield.

The 1903 model of the panoramic sight was described in the *Revue d'Artillerie*, Vol. 62, p. 127, but many improvements have been introduced recently. It appears to be very similar to the British panoramic sight, and can be used on the gun for direct or indirect laying, or on a tripod, or fixed to a shield, in any convenient position for examining the objective and the results of fire. The instrument issued for normal use for the latter purposes, however, has smaller magnifying power and a wider field of view than that used for sights. Those for the guns are carried in a box on each gun, that for observation on a wagon, and is fitted with a strap for carrying over the shoulder when required. All field batteries will shortly have this instrument issued to them.

The director was originally a semi-circular dial sight, but has been improved by the base plate being made a complete circle and by the addition of a telescope and of a magnetic compass. The base plate is graduated in millièmes (6,400 to the circle). The angle of site can also be read, the instrument being provided with a spirit level and a vertical scale for this purpose. It is mounted on a tripod capable of considerable adjustment for steep slopes. The instrument and its uses are described. If the target and the battery are not both visible from the observing station two instruments are required, and even with telephonic communication between them both and the battery it takes 20 minutes to make the observations and communicate the results so that ranging may begin.

The lunette à ciseaux (Scheren fernrohr) is used in the same manner as the cercle de pointage, except that having no compass it is of no use for ranging when the battery cannot be seen from the observing station. It consists of a stereoscopic arrangement of telescopes movable on a vertical pivot over a horizontal base plate. The two eye pieces are fixed to the pivot, and tubes and object glasses can be elevated to observe over a shield or screen, the observer remaining hidden, or depressed to the horizontal. In the latter case the object glasses are about 1 metre apart and the definition is excellent. In open positions the cercle de pointage would generally be used, as it is more easily manipulated, but in covered positions the lunette is better as the observer need not show himself. Both instruments are carried in the observing wagon, but can be withdrawn in their cases and carried in a special fitting on a saddle.

THE PART PLAYED BY THE ARTILLERY IN THE BATTLE OF VIETRISSA ON 10TH JULY, 1913.

By Major De Poilloüe de Saint Mars, of the Artillery.—In a recent article in the *Revue d'Artillerie* General Herr advocated the necessity for long-range guns, but it does not follow that a combatant must be reduced to silence if not in possession of such weapons. Battles are not won at long ranges, and field artillery can be usefully employed within their own range (5 k.m. or less) if carefully manœuvred out of sight of the heavier guns. When there, their superior rapidity of fire, their numbers, and their accuracy may overpower the heavier weapons. This was exemplified at the Battle of Vietrissa. Beaten at Denier Hissar and Doiran the Bulgarians retired behind the Stroumar, and took up a position with their heavy guns, which carry 9 kilometres. The Greeks had no long-range guns, and their advance was checked, but under cover of night they advanced their field artillery so close to the Bulgarian heavy guns that they were able to reduce them to silence. The Greek infantry then advanced, accompanied by mountain artillery, and the Bulgarians had to quit their position in haste, abandoning their heavy guns and several field guns.

CORRECTIONS TO THE GERMAN FIELD ARTILLERY MANŒUVRE REGULATIONS.

Since the last issue (1907) of these regulations about 200 correction slips have been issued, which can be divided into three series. The first, issued between 1909 and 1911, apply to the foot artillery. During this period fixed ammunition was introduced, the director replaced the dial sight, and aiming points and indirect fire were developed. The second series (1912) dealt with the mounted artillery and the 1913 series comprises a new edition of Chapter II.—foot artillery—and is only applicable to those units to which the panoramic sight has been issued.

Except as above the alterations are slight; the more important are as follows:—In the first series the salvo is omitted. In firing over friendly troops percussion fuze is to be substituted for time fuze when the first line reaches 300 yards from the enemy; the elevation is then raised to hinder the approach of the reserves. On the defensive, when the field artillery must come into the open to oppose the advancing infantry, the heavy artillery will, as a general rule, continue to fire on the enemy's artillery.

The second series includes orders for the observatory waggon, the semi-covered position is done away with, the position in observation is substituted for the position in readiness, and stress is laid on the necessity for obtaining concealment from the enemy's aircraft. The destruction, and not only the neutralization of the enemy's artillery, is enjoined, fresh orders are issued in regard to the duties of the artillery commanders, and considerable modifications are made in regard to acting in conjunction with the infantry. The important point is to liberate as soon as possible the mass of the field artillery to employ it against the enemy's infantry.

The most important of the 1913 series are those dealing with the supply of ammunition. It is laid down that if clear observations can be taken, the friendly infantry can advance to within 200 metres of the point of impact of shell fired with time fuzes, and 150 metres if percussion fuze is being used.

THE WINCHESTER SPORTING RIFLE, MODEL 1911.

This rifle is described and illustrated by a plate with several diagrams.

VARIOUS INFORMATION.

Contains a short description of the German observatory wagon and its contents. Its issue was not, at first, hailed with acclamation, but its uses are now well recognized.

A short description is given of the German 10-c.m. gun, M. 1904, also of the German 21-c.m. mortar battery.

September, 1913.

STUDY OF THE CUTTING PROPERTIES OF TOOL STEELS.

By P. Denis, Capt. of Artillery.—A tool steel is a steel hard enough to cut all metals, but the hardest steel is not necessarily the best for tools. It must also possess toughness. Tool steels can best be classified by their output, *i.e.* by the volume of metal which they will remove in a given time before becoming so blunt as to require re-sharpening. The machine invented by Mr. E. Herbert of Manchester is the best for measuring this output, and is described and illustrated by diagrams.

The aim of this article is to study the cutting properties of tool steels according to the thermic treatment they receive during manufacture, and to deduce from this the best processes to subject the steel to, in order to obtain suitable qualities for the various requirements of a machine shop.

The article is clearly written and is interesting.—(*To be continued*).

EFFECT OF THE RECOIL OF A GUN ON THE STABILITY OF AN AEROPLANE.

By Capt. A. Alayrac of the Artillery.—The probable effect is worked out theoretically, by the aid of the higher mathematics, for a gun recoiling with a force of 700 to 800 k.g. in a space of ·05 second. The results deduced are that such a gun may be placed anywhere within 1 metre of the centre of gravity of the machine without exerting a seriously disturbing effect, but that it would be prudent to arrange for the centre of rotation to be as near as possible to the transverse axis of inertia.

MECHANICAL FUZES.

By Capt. C. Roger-Vasselin.—In this article it is proposed :—

(1). To point out the reasons calling for the replacement of combustion fuzes by fuzes of purely mechanical action.

(2). To classify the various types of fuzes now existing.

(3). To study briefly each of the groups, selecting in each its most characteristic examples.

(4). To study, independently of the general classification, certain details such as safety appliances, etc.

The combustion fuze is considered to be doomed. It is very large and heavy, and its rate of combustion is altered by prolonged storage, and even varies from day to day owing to differences of atmospheric pressure.

Fuzes may be classified as follows:—

(1). Those depending for their action on the inertia of some part of the mechanism, or on the resistance of the air.

(2). Those depending on the flow of a liquid.

(3). Clockwork fuzes.

The principles of the first group are described, and a long list of makers is given. Among these the fuzes of Berdan, 1880, Neesen, 1885, Mieciche, 1885, Nordenfelt, 1890, Ludra, 1892, were described in the *Revue d'Artillerie* of September, 1895, by Capt. Bloch. Those of Keeson, 1894, Merek, 1900, MacEvoy, 1898, and Mauberge, 1895, are here described and illustrated. Compared with those of the second and third groups they are inferior, owing to the irregularity of their action. This is partly inherent to the design, and partly owing to the varying velocities of revolution of different projectiles. The former defect cannot be overcome, and it appears practically that the latter can only be obviated by making a different fuze for each type of gun, and even for the same gun if it is fired with varying charges. In this respect the interchangeable combustion fuze has a decided advantage. Again, the pendulum, or vane, if projecting outside the fuze, has to be removed for transport, which leads to waste of time in refixing it when the fuze is to be used. These fuzes are, therefore, of little practical use.—(*To be continued*).

The Webley-Fosbery Automatic Revolver.

A description of this revolver is given and illustrated by a plate containing 10 diagrams.

Various Information.

Contains a list of patents, mostly German, and specifications of projectiles designed for firing against balloons and dirigibles. These are either incendiary shell, or are intended to tear large holes in the envelope, and resemble the old chain-shot.

A short description is given of the German heavy 15 c.m. (5·9 in.) howitzer M. 1902.

October, 1913.

Trinitrotoluine.

A description is given of the composition, manufacture and chemical and physical properties of this explosive.

Mechanical Fuzes.

This article is continued with descriptions of the fuzes in the 2nd and 3rd groups. As examples of the 2nd group the fuzes of Tremel (1865) and Smith are explained and illustrated, and of the 3rd group those of Hanel (1895), Baker (1904), Schneider and Krupp. The author's conclusions are that the clockwork fuzes have considerable advantages over the others from the points of view of size, weight, keeping properties, ease of manipulation and regularity. They are practically a necessity for long range guns, as the size of the ordinary combustion time fuze becomes far too great.—(*To be continued*).

CUTTING PROPERTIES OF TOOL STEELS.

This article is continued, and is accompanied by various diagrams showing the relations between the output and the rapidity of stroke for different qualities of steel, so-called "power curves," and curves of output with and without a liquid (oil or water) to cool the tool. The hardness and toughness of a steel varies with its temperature; the toughness first diminishes as the temperature rises, and then increases again at higher temperatures. Similarly the hardness first diminishes and then increases. The greatest output is obtained when the cutting edge attains a temperature at which the hardness and toughness are both maxima. Some steels give their maximum output at two different temperatures, separated by a critical temperature at which the output is low. If the tool passes the critical point without being blunted it will continue to give good results at the higher temperature without further sharpening. The temperature of the cutting edge depends on the rapidity of the stroke, the depth and width of the cut and the hardness of the metal to be cut, and the best temperature to work at can be determined by Herbert's machine. The article is clearly expressed, and would be of great interest and value to anyone engaged in manufacturing operations involving the use of steel tools for shaping metals.—(*To be continued*).

VARIOUS INFORMATION.

Italy, Reorganization of the Artillery.—The reorganization decided upon in 1910 brings the strength to :—

36 regiments of field artillery (12 corps and 24 divisional) = 193 batteries, 36 depôt batteries, and 36 train companies.

2 regiments heavy field artillery = 20 batteries and 2 depôt batteries.

1 regiment horse artillery = 8 batteries, 1 depôt battery and 4 train companies.

2 regiments mountain artillery = 24 batteries and 2 depôt batteries.

10 regiments fortress artillery = 98 companies and 10 depôt companies

An addition of 19 regiments in all, of which the raising of six only is immediately ordered.

A Royal decree in 1911 also added 10 groups (each of 3 batteries) to replace a part of the units sent "provisionally" to Tripoli.

Adding the figures for increases in the infantry, cavalry and engineers this amounts to the creation of a new *corps d'armée*.

England—Tetranitaniline.—The composition and characteristics of this explosive are shortly described, and it is compared in tabular form with gun-cotton, picric acid and trinitrotolnol.

Germany.—A short notice is given of illuminating and incendiary shell.

A.R.R.